Engineering Data

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12.1 Standard Specifications for Pressure-Retaining Materials

See *Section 12.2* *for additional specifications, cross-referenced to material code numbers.*

1. Cast Carbon Steel ASTM A216 Grade WCC:

Temperature range:

- *-20 to 800 °F (-30 to 427 °C)*

Composition (%):
- *C = 0.25 max*
- *Mn = 1.2 max*
- *P = 0.035 max*
- *S = 0.035 max*
- *Si = 0.6 max*

2. Cast Carbon Steel ASTM A352 Grade LCC:

Temperature range:
- *-50 to 650 °F (-45 to 343 °C)*

Composition (%):
- *Same as ASTM A216 grade WCC*

3. Carbon Steel Bar AISI 1018, UNS G10180:

Temperature range:
- *-20 to 800 °F (-29 to 427 °C)*

Composition (%):
- *C = 0.14 to 0.2*
- *Mn = 0.6 to 0.9*
- *P = 0.04 max*
- *S = 0.05 max*

4. Leaded Steel Bar AISI 12L14, UNS G12144:

Temperature range:
- *-20 to 800 °F (-29 to 427 °C)*

Composition (%):
- *C = 0.15 max*
- *Mn = 0.85 to 1.15*
- *P = 0.04 to 0.09*
- *S = 0.26 to 0.35*
- *Pb = 0.15 to 0.35*

5. AISI 4140 Cr-Mo Steel:

Similar to ASTM A193 Grade B7 bolt material.

Temperature range:
- *-55 to 1000 °F (-48 to 538 °C)*

Composition (%):
- *C = 0.38 to 0.43*
- *Mn = 0.75 to 1.0*
- *P = 0.035 max*
- *S = 0.040 max*
- *Si = 0.15 to 0.35*
- *Cr = 0.8 to 1.1*
- *Mo = 0.15 to 0.25*
- *Fe = Remainder*

6. Forged 3-1/2% Nickel Steel ASTM A352 Grade LC3:

Temperature range:
- *-150 to 650 °F (-101 to 343 °C)*

Composition (%):
- *C = 0.15 max*
- *Mn = 0.5 to 0.8*
- *P = 0.04 max*
- *S = 0.045 max*
- *Si = 0.6 max*
- *Ni = 3.0 to 4.0*

7. Cast Cr-Mo Steel ASTM A217 Grade WC6:

Temperature range:
- *-20 to 1100 °F (-30 to 595 °C)*

Composition (%):
- *C = 0.05 to 0.2*
- *Mn = 0.5 to 0.8*
- *P = 0.035 max*
- *S = 0.035 max*
- *Si = 0.60 max*
- *Cr = 1.0 to 1.5*
- *Mo = 0.45 to 0.65*

8. Cast Cr-Mo Steel ASTM A217 Grade WC9:

Temperature range:
- *-20 to 1100 °F (-30 to 595 °C)*

Composition (%):
- *C = 0.05 to 0.18*
- *Mn = 0.4 to 0.7*
- *P = 0.035 max*
- *S = 0.035 max*
- *Si = 0.6 max*
- *Cr = 2.0 to 2.75*
- *Mo = 0.9 to 1.2*

9. Forged Cr-Mo Steel ASTM A182 Grade F22:

Temperature range:
- *-20 to 1100 °F (-30 to 593 °C)*

Composition (%):
- *C = 0.05 to 0.15*
- *Mn = 0.3 to 0.6*
- *P = 0.04 max*
- *S = 0.04 max*
- *Si = 0.5 max*
- *Cr = 2.0 to 2.5*
- *Mo = 0.87 to 1.13*

10. Cast Cr-Mo Steel ASTM A217 Grade C5:

Temperature range:
- *-20 to 1200 °F (-30 to 649 °C)*

Composition (%):
- *C = 0.2 max*
- *Mn = 0.4 to 0.7*
- *P = 0.04 max*
- *S = 0.045 max*
- *Si = 0.75 max*
- *Cr = 4.0 to 6.5*
- *Mo = 0.45 to 0.65*

11. Type 302 Stainless Steel ASTM A479 Grade UNS S30200:

Temperature range:
- *-325 to 750 °F (-198 to 399°C)*

Composition (%):
- *C = 0.15 max*
- *Mn = 2.0 max*
- *P = 0.045 max*
- *S = 0.03 max*
- *Si = 1.0 max*
- *Cr = 17.0 to 19.0*
- *Ni = 8.0 to 10.0*
- *N = 0.1 max*
- *Fe = Remainder*

12. Type 304L Stainless Steel ASTM A479 Grade UNS S30403:

Temperature range:
- *-425 to 800 °F (-254 to 425 °C)*

Composition (%):
- *C = 0.03 max*
- *Mn = 2.0 max*
- *P = 0.045 max*
- *S = 0.03 max*
- *Si = 1.0 max*
- *Cr = 18.0 to 20.0*
- *Ni = 8.0 to 12.0*
- *Fe = Remainder*

13. Cast Type 304L Stainless Steel ASTM A351 Grade CF3:

Temperature range:
- *-425 to 800 °F (-254 to 425°C)*

Composition (%):
- *C = 0.03 max*
- *Mn = 1.5 max*
- *Si = 2.0 max*
- *S = 0.040 max*
- *P = 0.040 max*
- *Cr = 17.0 to 21.0*
- *Ni = 8.0 to 11.0*
- *Mo = 0.50 max*

14. Type 316L Stainless Steel ASTM A479 Grade UNS S31603:

Temperature range:

- *-425 to 850 °F (-254 to 450 °C)*

Composition (%):

- *C = 0.03 max*
- *Mn = 2.0 max*
- *P = 0.045 max*
- *S = 0.03 max*
- *Si = 1.0 max*
- *Cr = 16.0 to 18.0*
- *Ni = 10.0 to 14.0*
- *Mo = 2.0 to 3.0*
- *Fe = Remainder*

15. Type 316 Stainless Steel ASTM A479 Grade UNS S31600:

Temperature range:

- *-425 to 1500 °F (-255 to 816 °C)*
- *Above 1000 °F (538 °C), 0.04 C minimum required*

Composition (%):

- *C = 0.08 max*
- *Mn = 2.0 max*
- *P = 0.045 max*
- *S = 0.03 max*
- *Si = 1.0 max*
- *Cr = 16.0 to 18.0*
- *Ni = 10.0 to14.0*
- *Mo = 2.0 to 3.0*
- *Fe = Remainder*

16. Cast Type 316 Stainless Steel ASTM A351 Grade CF8M:

Temperature range:

- *-425 to 1500 °F (-254 to 816 °C)*
- *Above 1000 °F (538 °C), 0.04 C minimum required*

Composition (%):

- *C = 0.08 max*
- *Mn = 1.5 max*
- *Si = 1.5 max*
- *P = 0.04 max*
- *S = 0.04 max*
- *Cr = 18.0 to 21.0*
- *Ni = 9.0 to 12.0*
- *Mo = 2.0 to 3.0*

17. Type 317 Stainless Steel ASTM A479 Grade UNS S31700:

Temperature range:

- *-325 to 1500 °F (-198 to 816 °C)*
- *Above 1000 °F (538 °C), 0.04 C minimum required*

Composition (%):

- *C = 0.08 max*
- *Mn = 2.0 max*
- *P = 0.045 max*
- *S = 0.03 max*
- *Si = 1.0 max*
- *Cr = 18.0 to 20.0*
- *Ni = 11.0 to15.0*
- *Mo = 3.0 to 4.0*
- *Fe = Remainder*

18. Cast Type 317 Stainless Steel ASTM A351 Grade CG8M:

Temperature range:

- *-325 to 1000 °F (-198 to 538 °C)*

Composition (%):

- *C = 0.08 max*
- *Mn = 1.5 max*
- *Si = 1.5 max*
- *P = 0.04 max*
- *S = 0.04 max*
- *Cr = 18.0 to 21.0*
- *Ni = 9.0 to 13.0*
- *Mo = 3.0 to 4.0*

19. Type 410 Stainless Steel ASTM A479 Grade S41000:

Temperature range:

- *-20 to 1000 °F (-29 to 538 °C)*

Composition (%):

- *C = 0.08 to 0.15*
- *Mn = 1.0 max*
- *P = 0.04 max*
- *S = 0.03 max*
- *Si = 1.0 max*
- *Cr = 11.5 to 13.5*
- *Fe = Remainder*

20. Type 17-4PH Stainless Steel ASTM A564 Grade 630, UNS S17400:

Temperature range:
- *-20 to 650 °F (-29 to 343 °C)*

Composition (%):
- *C = 0.07 max*
- *Mn = 1.0 max*
- *Si = 1.0 max*
- *P = 0.04 max*
- *S = 0.03 max*
- *Cr = 15.0 to 17.5*
- *Nb = 0.15 to 0.45*
- *Cu = 3.0 to 5.0*
- *Ni = 3.0 to 5.0*
- *Fe = Remainder*

21. Type 254 SMO Stainless Steel ASTM A479 Grade UNS S31254:

Temperature range:
- *-325 to 750 °F (-198 to 399 °C)*

Composition (%):
- *C = 0.02 max*
- *Mn = 1.0 max*
- *P = 0.03 max*
- *S = 0.01 max*
- *Si = 0.8 max*
- *Cr = 18.5 to 20.5*
- *Ni = 17.5 to 18.5*
- *Mo = 6.0 to 6.5*
- *N = 0.18−0.22*
- *Fe = Remainder*

22. Cast Type 254 SMO Stainless Steel ASTM A351 Grade CK3MCuN:

Temperature range:
- *-325 to 750 °F (-198 to 399 °C)*

Composition (%):
- *C = 0.025 max*
- *Mn = 1.2 max*
- *Si = 1.0 max*
- *P = 0.045 max*
- *S = 0.01 max*
- *Cr = 19.5 to 20.5*
- *Ni = 17.5 to 19.5*
- *Mo = 6.0 to 7.0*
- *N = 0.18 to 0.24*

23. Type 2205, S31803 Duplex Stainless Steel ASTM A479 Grade UNS S31803:

Temperature range:
- *-60 to 600 °F (-50 to 316 °C)*

Composition (%):
- *C = 0.03 max*
- *Mn = 2.0 max*
- *P = 0.03 max*
- *S = 0.02 max*
- *Si = 1.0 max*
- *Cr = 21.0 to 23.0*
- *Ni = 4.5 to 6.5*
- *Mo = 2.5 to 3.5*
- *N = 0.08 to 0.2*
- *Fe = Remainder*

24. Cast Type 2205, S31803 Stainless Steel ASTM A890 Grade 4a, CD3MN:

Temperature range:
- *-60 to 600 °F (-50 to 316 °C)*

Composition (%):
- *C = 0.03 max*
- *Mn = 1.5 max*
- *Si = 1.0 max*
- *P = 0.04 max*
- *S = 0.02 max*
- *Cr = 21.0 to 23.5*
- *Ni = 4.5 to 6.5*
- *Mo = 2.5 to 3.5*
- *Cu = 1.0 max*
- *N = 0.1 to 0.3*
- *Fe = Remainder*

25. Cast Iron ASTM A126 Class B, UNS F12102:

Temperature range:
- *-20 to 450 °F (-29 to 232 °C)*

Composition (%):
- *P = 0.75 max*
- *S = 0.15 max*

26. Cast Iron ASTM A126 Class C, UNS F12802:

Temperature range:
- *-20 to 450 °F (-29 to 232 °C)*

Composition (%):
- *P = 0.75 max*
- *S = 0.15 max*

27. Ductile Iron ASTM A395 Type 60-40-18:

Temperature range:
- *-20 to 650 °F (-29 to 343 °C)*

Composition (%):
- *C = 3.0 min*
- *Si = 2.5 max*
- *P = 0.08 max*

28. Ductile Ni-Resist Iron ASTM A439 Type D-2B, UNS F43001:

Temperature range for non-pressure-retaining components:
- *-20 to 1400 °F (-29 to 760 °C)*

Composition (%):
- *C = 3.0 max*
- *Si = 1.5 to 3.00*
- *Mn = 0.70 to 1.25*
- *P = 0.08 max*
- *Ni = 18.0 to 22.0*
- *Cr = 2.75 to 4.0*

29. Leaded Tin Bronze ASTM B61, UNS C92200:

Temperature range:
- *-325 to 550 °F (-198 to 288 °C)*

Composition (%):
- *Cu = 86.0 to 90.0*
- *Sn = 5.5 to 6.5*
- *Pb = 1.0 to 2.0*
- *Zn = 3.0 to 5.0*
- *Ni = 1.0 max*
- *Fe = 0.25 max*
- *S = 0.05 max*
- *P = 0.05 max*

30. Tin Bronze ASTM B584 Grade UNS C90500:

Temperature range:
- *-325 to 400 °F (-198 to 204 °C)*

Composition (%):
- *Cu = 86.0 to 89.0*
- *Sn = 9.0 to 11.0*
- *Pb = 0.30 max*
- *Zn = 1.0 to 3.0*
- *Ni = 1.0 max*
- *Fe = 0.2 max*
- *S = 0.05 max*
- *P = 0.05 max*

31. Manganese Bronze ASTM B584 Grade UNS C86500:

Temperature range:
- *-325 to 350 °F (-198 to 177 °C)*

Composition (%):
- *Cu = 55.0 to 60.0*
- *Sn = 1.0 max*
- *Pb = 0.4 max*
- *Ni = 1.0 max*
- *Fe = 0.4 to 2.0*
- *Al = 0.5 to 1.5*
- *Mn = 0.1 to 1.5*
- *Zn = 36.0 to 42.0*

32. Cast Aluminum Bronze ASTM B148 Grade UNS C95400:

Temperature range:
- *-325 to 600 °F (-198 to 316 °C)*

Composition (%):
- *Cu = 83.0 min*
- *Al = 10.0 to 11.5*
- *Fe = 3.0 to 5.0*
- *Mn = 0.50 max*
- *Ni = 1.5 max*

33. Cast Aluminum Bronze ASTM B148 Grade UNS C95800:

Temperature range:

- *-325 to 500 °F (-198 to 260 °C)*

Composition (%):

- *Cu = 79.0 min*
- *Al = 8.5 to 9.5*
- *Fe = 3.5 to 4.5*
- *Mn = 0.8 to 1.5*
- *Ni = 4.0 to 5.0*
- *Si = 0.1 max*

34. B16 Yellow Brass Bar ASTM B16 Grade UNS C36000, 1/2 Hard:

Temperature range for non-pressure- retaining components:

- *-325 to 400 °F (-198 to 204 °C)*

Composition (%):

- *Cu = 60.0 to 63.0*
- *Pb = 2.5 to 3.0*
- *Fe = 0.35 max*
- *Zn = Remainder*

35. Naval Brass Forgings ASTM B283 Alloy UNS C46400:

Temperature range:

- *-325 to 400 °F (-198 to 204 °C)*

Composition (%):

- *Cu = 59.0 to 62.0*
- *Sn = 0.5 to 1.0*
- *Pb = 0.2 max*
- *Fe = 0.15 max*
- *Zn = Remainder*

36. Aluminum Bar ASTM B211 Alloy UNS A96061-T6:

Temperature range:

- *-452 to 400 °F (-269 to 204 °C)*

Composition (%):

- *Si = 0.4 to 0.8*
- *Fe = 0.7 max*
- *Cu = 0.15 to 0.4*
- *Zn = 0.25 max*
- *Mg = 0.8 to 1.2*
- *Mn = 0.15 max*
- *Cr = 0.04 to 0.35*
- *Ti = 0.15 max*
- *Other Elements = 0.15 max*
- *Al = Remainder*

37. Cobalt-base Alloy No.6 Cast UNS R30006, Weld filler CoCr-A:

Temperature range for non-pressure-retaining components:

- *-325 to 1800 °F (-198 to 980 °C)*

Composition (%):

- *C = 0.9 to 1.4*
- *Mn = 1.0 max*
- *W = 3.5 to 6.0*
- *Ni = 3.0 max*
- *Cr = 26.0 to 31.0*
- *Mo = 1.5 max*
- *Fe = 3.0 max*
- *Si = 1.5 max*
- *Co = Remainder*

38. Ni-Cu Alloy Bar K500 ASTM B865 Grade N05500:

Temperature range for non-pressure-retaining components:

- *-325 to 900 °F (-198 to 482 °C)*

Composition (%):

- *Ni = 63.0 min*
- *Fe = 2.0 max*
- *Mn = 1.5 max*
- *Si = 0.5 max*
- *C = 0.18 max*
- *S = 0.01 max*
- *Al = 2.3 to 3.15*
- *Ti = 0.35 to 0.85*
- *Cu = Remainder*

39. Cast Ni-Cu Alloy 400 ASTM A494 Grade M35-1:

Temperature range:

- *-325 to 900 °F (-198 to 475 °C)*

Composition (%):

- *Cu = 27.0 to 33.0*
- *C = 0.35 max*
- *Mn = 1.5 max*
- *Fe = 3.5 max*
- *S = 0.02 max*
- *P = 0.03 max*
- *Si = 1.25 max*
- *Nb = 0.5 max*
- *Ni = Remainder*

40. Ni-Cr-Mo Alloy C276 Bar ASTM B574 Grade N10276:

Temperature range:
- *-325 to 1250 °F (-198 to 677 °C)*

Composition (%):
- *Cr = 14.5 to 16.5*
- *Fe = 4.0 to 7.0*
- *W = 3.0 to 4.5*
- *C = 0.01 max*
- *Si = 0.08 max*
- *Co = 2.5 max*
- *Mn = 1.0 max*
- *V = 0.35 max*
- *Mo = 15.0 to 17.0*
- *P = 0.04*
- *S = 0.03*
- *Ni = Remainder*

41. Ni-Cr-Mo Alloy C ASTM A494 CW2M:

Temperature range:
- *-325 to 1000 °F (-198 to 538 °C)*

Composition (%):
- *Cr = 15.5 to 17.5*
- *Fe = 2.0 max*
- *W = 1.0 max*
- *C = 0.02 max*
- *Si = 0.8 max*
- *Mn = 1.0 max*
- *Mo = 15.0 to 17.5*
- *P = 0.03*
- *S = 0.02*
- *Ni = Remainder*

42. Ni-Mo Alloy B2 Bar ASTM B335 Grade B2, UNS N10665:

Temperature range:
- *-325 to 800 °F (-198 to 427 °C)*

Composition (%):
- *Cr = 1.0 max*
- *Fe = 2.0 max*
- *C = 0.02 max*
- *Si = 0.1 max*
- *Co = 1.0 max*
- *Mn = 1.0 max*
- *Mo = 26.0 to 30.0*
- *P = 0.04 max*
- *S = 0.03 max*
- *Ni = Remainder*

43. Cast Ni-Mo Alloy B2 ASTM A494 N7M:

Temperature range:
- *-325 to 1000 °F (-198 to 538 °C)*

Composition (%):
- *Cr = 1.0 max*
- *Fe = 3.0 max*
- *C = 0.07 max*
- *Si = 1.0 max*
- *Mn = 1.0 max*
- *Mo = 30.0 to 33.0*
- *P = 0.03 max*
- *S = 0.02 max*
- *Ni = Remainder*

12.2 Material Properties for Pressure-Containing Components

The material codes in this table correspond to the standard specifications for materials listings in *Section 12.1*.

Material Code	Minimum Mechanical Properties				Modulus of Elasticity at 70 °F (21 °C) psi (MPa)	Typical Brinell Hardness
	Tensile Strength ksi (MPa)	Yield Strength ksi (MPa)	Elongation in 2-in. (50 mm)	Reduction in Area (%)		
1	70-95 (485-655)	40 (275)	22	35	27.9E6 (19.2E4)	137-187
2	70-95 (485-655)	40 (275)	22	35	27.9E6 (19.2E4)	137-187
3	57 (390) typical	42 (290) typical	37 typical	67 typical	30.0E6 (20.7E4)	111
4	79 (545) typical	71 (490) typical	16 typical	52 typical	30.0E6 (20.7E4)	163
5[1]	125 (860)	105 (725) typical	16	50	29.9E6 (20.6E4)	258
6	70-95 (485-655)	40 (275)	24	35	27.9E6 (19.2E4)	140-190
7	70-95 (485-655)	40 (275)	20	35	29.9E6 (20.6E4)	147-200
8	70-95 (485-655)	40 (275)	20	35	29.9E6 (20.6E4)	147-200
9	75-100 (515-690)	45(310)	19	40	29.9E6 (20.6E4)	156-207 required
10	90-115 (620-795)	60 (415)	18	35	27.4E6 (19.0E4)	176-255
11	75 (515)	30 (205)	30	40	28.3E6 (19.3E4)	150
12	70 (485)	25 (170)	30	40	29.0E6 (20.0E4)	150
13	70 (485)	30 (205)	35	–	29.0E6 (20.0E4)	150
14	70 (485)	25 (170)	40	50	28.3E6 (19.3E4)	150-170
15[2]	75 (515)	30 (205)	30	40	28.3E6 (19.5E4)	150
16	70 (485)	30 (205)	30	–	28.3E6 (19.5E4)	163
17	75 (515)	30 (205)	30	40	28.3E6 (19.5E4)	170
18	75 (515)	35 (240)	25	–	28.3E6 (19.5E4)	170
19[3]	70 (480)	40 (275)	20	45	29.2E6 (20.1E4)	241
20[4]	145 (1000)	125 (860)	13	45	29E6 (20.0E4)	311 min
21	95 (665)	45 (310)	35	50	29.0E6 (20.0E4)	90 HRB
22	80 (550)	38 (260)	35	–	29.0E6 (20.0E4)	82 HRB
23	90 (620)	65 (450)	25	–	30.5E6 (21.0E4)	290 max
24	90 (620)	65 (450)	25	–	30.5E6 (21.0E4)	98 HRB
25[5]	31 (214)	–	–	–	13.4E6 (9.2E4)	160-220
26[6]	41 (282)	–	–	–	13.4E6 (9.2E4)	230
27	60 (415)	40 (276)	18	–	23E6 (16E4)	143-187
28	58 (400)	30 (205)	8	–	–	139-202
29	34 (234)	16 (110)	24	–	14.0E6 (9.7E4)	65
30	40 (275)	18 (124)	20	–	14.0 (9.7E4)	75
31	65 (448)	25 (172)	20	–	15.3E6 (10.5E4)	97

12.2 Material Properties for Pressure-Containing Components, continued.

Material Code	Minimum Mechanical Properties				Modulus of Elasticity at 70 °F (21 °C) psi (MPa)	Typical Brinell Hardness
	Tensile Strength ksi (MPa)	Yield Strength ksi (MPa)	Elongation in 2-in. (50 mm)	Reduction in Area (%)		
32	75 (515)	30 (205)	12	–	16E6 (11.0E4)	150 min
33	85 (585)	35 (240)	15	–	16E6 (11.0E4)	159
34	55 (380)	25 (170)	10	–	14E6 (9.6E4)	55-75 HRB required
35	60 (415)	27 (185)	25	–	15.0E6 (10.3E4)	131-142
36	42 (290)	35 (241)	10	–	9.9E6 (6.8E4)	95
37[7]	154 (1060) typical	93 (638) typical	17 typical	–	30E6 (21E4)	37 HRC
38	140 (965)	100 (690)	20	–	26E6 (17.9E4)	265-325
39	65 (450)	25 (170)	25	–	23E6 (15.8E4)	110-150
40	100 (689)	41 (283)	40	–	29.8E6 (20.5E4)	210
41	72 (496)	40 (275)	20	–	30.8E6 (21.2E4)	150-185
42	110 (760)	51 (350)	40	–	31.4E6 (21.7E4)	238
43	76 (525)	40 (275)	20	–	28.5E6 (19.7E4)	180

1. Tempered 1200 °F (650 °C).
2. Annealed.
3. ASTM A479 Annealed Condition.
4. ASTM A564 Grade 630 Condition H1075.
5. A126 Cl.B 1.125-in. (95 mm) diameter bar.
6. A126 Cl.C 1.125-in. (95 mm) diameter bar.
7. Wrought.

12.3 Physical Constants of Hydrocarbons

No.	Compound	Formula	Molecular Weight	Boiling Point at 14.696 psia (°F)	Vapor Pressure at 100 °F (psia)	Freezing Point at 14.696 psia (°F)
1	Methane	CH_4	16.043	-258.69	(5000)[1]	-296.46[2]
2	Ethane	C_2H_6	30.070	-127.48	(800)[1]	-297.89[2]
3	Propane	C_3H_8	44.097	-43.67	190	-305.84[2]
4	n–Butane	C_4H_{10}	58.124	31.10	51.6	-217.05
5	Isobutane	C_4H_{10}	58.124	10.90	72.2	-255.29
6	n–Pentane	C_5H_{12}	72.151	96.92	15.570	-201.51
7	Isopentane	C_5H_{12}	72.151	82.12	20.44	-255.83
8	Neopentane	C_5H_{12}	72.151	49.10	35.90	2.17
9	n–Hexane	C_6H_{14}	86.178	155.72	4.956	-139.58
10	2–Methylpentane	C_6H_{14}	86.178	140.47	6.767	-244.63
11	3–Methylpentane	C_6H_{14}	86.178	145.89	6.098	–
12	Neohexane	C_6H_{14}	86.178	121.52	9.856	-147.72
13	2,3–Dimethylbutane	C_6H_{14}	86.178	136.36	7.404	-199.38

No.	Compound	Formula	Critical Constants		Specific Gravity at 14.696 psia	
			Critical Temperature (°F)	Critical Pressure (psia)	Liquid [3,4] 60/60 °F	Gas at 60 °F (Air=1)[5]
1	Methane	CH_4	-116.63	667.8	0.3[6]	0.5539
2	Ethane	C_2H_6	90.09	707.8	0.3564[7]	1.0382
3	Propane	C_3H_8	206.01	616.3	0.5077[7]	1.5225
4	n–Butane	C_4H_{10}	305.65	550.7	0.5844[7]	2.0068
5	Isobutane	C_4H_{10}	274.98	529.1	0.5631[7]	2.0068
6	n–Pentane	C_5H_{12}	385.7	488.6	0.6310	2.4911
7	Isopentane	C_5H_{12}	369.10	490.4	0.6247	2.4911
8	Neopentane	C_5H_{12}	321.13	464.0	0.5967[7]	2.4911
9	n–Hexane	C_6H_{14}	453.7	436.9	0.6640	2.9753
10	2–Methylpentane	C_6H_{14}	435.83	436.6	0.6579	2.9753
11	3–Methylpentane	C_6H_{14}	448.3	453.1	0.6689	2.9753
12	Neohexane	C_6H_{14}	420.13	446.8	0.6540	2.9753
13	2,3–Dimethylbutane	C_6H_{14}	440.29	453.5	0.6664	2.9753

12.3 Physical Constants of Hydrocarbons, continued.

No.	Compound	Formula	Molecular Weight	Boiling Point at 14.696 psia (°F)	Vapor Pressure at 100 °F (psia)	Freezing Point at 14.696 psia (°F)
14	n–Heptane	C_7H_{16}	100.205	209.17	1.620	-131.05
15	2–Methylhexane	C_7H_{16}	100.205	194.09	2.271	-180.89
16	3–Methylhexane	C_7H_{16}	100.205	197.32	2.130	–
17	3–Ethylpentane	C_7H_{16}	100.205	200.25	2.012	-181.48
18	2,2–Dimethylpentane	C_7H_{16}	100.205	174.54	3.492	-190.86
19	2,4–Dimethylpentane	C_7H_{16}	100.205	176.89	3.292	-182.63
20	3,3–Dimethylpentane	C_7H_{16}	100.205	186.91	2.773	-210.01
21	Triptane	C_7H_{16}	100.205	177.58	3.374	-12.82
22	n–Octane	C_8H_{18}	114.232	258.22	0.537	-70.18
23	Disobutyl	C_8H_{18}	114.232	228.39	1.101	-132.07
24	Isooctane	C_8H_{18}	114.232	210.63	1.708	-161.27
25	n–Nonane	C_9H_{20}	128.259	303.47	0.179	-64.28
26	n–Decane	$C_{10}H_{22}$	142.286	345.48	0.0597	-21.36
27	Cyclopentane	C_5H_{10}	70.135	120.65	9.914	-136.91
28	Methylcyclopentane	C_6H_{12}	84.162	161.25	4.503	-224.44

No.	Compound	Formula	Critical Constants		Specific Gravity at 14.696 psia	
			Critical Temperature (°F)	Critical Pressure (psia)	Liquid [3,4] 60/60 °F	Gas at 60 °F (Air=1)[5]
14	n–Heptane	C_7H_{16}	512.8	396.8	0.6882	3.4596
15	2–Methylhexane	C_7H_{16}	495.00	396.5	0.6830	3.4596
16	3–Methylhexane	C_7H_{16}	503.78	408.1	0.6917	3.4596
17	3–Ethylpentane	C_7H_{16}	513.48	419.3	0.7028	3.4596
18	2,2–Dimethylpentane	C_7H_{16}	477.23	402.2	0.6782	3.4596
19	2,4–Dimethylpentane	C_7H_{16}	475.95	396.9	0.6773	3.4596
20	3,3–Dimethylpentane	C_7H_{16}	505.85	427.2	0.6976	3.4596
21	Triptane	C_7H_{16}	496.44	428.4	0.6946	3.4596
22	n–Octane	C_8H_{18}	564.22	360.6	0.7068	3.9439
23	Disobutyl	C_8H_{18}	530.44	360.6	0.6979	3.9439
24	Isooctane	C_8H_{18}	519.46	372.4	0.6962	3.9439
25	n–Nonane	C_9H_{20}	610.68	332.0	0.7217	4.4282
26	n–Decane	$C_{10}H_{22}$	652.1	304.0	0.7342	4.9125
27	Cyclopentane	C_5H_{10}	461.5	653.8	0.7504	2.4215
28	Methylcyclopentane	C_6H_{12}	499.35	548.9	0.7536	2.9057

12.3 Physical Constants of Hydrocarbons, continued.

No.	Compound	Formula	Molecular Weight	Boiling Point at 14.696 psia (°F)	Vapor Pressure at 100 °F (psia)	Freezing Point at 14.696 psia (°F)
29	Cyclohexane	C_6H_{12}	84.162	177.29	3.264	43.77
30	Methylcyclohexane	C_7H_{14}	98.189	213.68	1.609	-195.87
31	Ethylene	C_2H_4	28.054	-154.62	–	-272.45[2]
32	Propene	C_3H_6	42.081	-53.90	226.4	-301.45[2]
33	1–Butene	C_4H_8	56.108	20.75	63.05	-301.63[2]
34	Cis–2–Butene	C_4H_8	56.108	38.69	45.54	-218.06
35	Trans–2–Butene	C_4H_8	56.108	33.58	49.80	-157.96
36	Isobutene	C_4H_8	56.108	19.59	63.40	-220.61
37	1–Pentene	C_5H_{10}	70.135	85.93	19.115	-265.39
38	1,2–Butadiene	C_4H_6	54.092	51.53	(20.0)[1]	-213.16
39	1,3–Butadiene	C_4H_6	54.092	24.06	(60.0)[1]	-164.02
40	Isoprene	C_5H_8	68.119	93.30	16.672	-230.74
41	Acetylene	C_2H_2	26.038	-119.0[8]	–	-114.0[2]
42	Benzene	C_6H_6	78.114	176.17	3.224	41.96
43	Toluene	C_7H_8	92.141	231.13	1.032	-138.94

No.	Compound	Formula	Critical Constants		Specific Gravity at 14.696 psia	
			Critical Temperature (°F)	Critical Pressure (psia)	Liquid [3,4] 60/60 °F	Gas at 60 °F (Air=1)[1]
29	Cyclohexane	C_6H_{12}	536.7	591.0	0.7834	2.9057
30	Methylcyclohexane	C_7H_{14}	570.27	503.5	0.7740	3.3900
31	Ethylene	C_2H_4	48.58	729.8	–	0.9686
32	Propene	C_3H_6	196.9	669.0	0.5220[7]	1.4529
33	1–Butene	C_4H_8	295.6	583.0	0.6013[7]	1.9372
34	Cis–2–Butene	C_4H_8	324.37	610.0	0.6271[7]	1.9372
35	Trans–2–Butene	C_4H_8	311.86	595.0	0.6100[7]	1.9372
36	Isobutene	C_4H_8	292.55	580.0	0.6004[7]	1.9372
37	1–Pentene	C_5H_{10}	376.93	590.0	0.6457	2.4215
38	1,2–Butadiene	C_4H_6	(339.0)[1]	(653.0)[1]	0.6587	1.8676
39	1,3–Butadiene	C_4H_6	306.0	628.0	0.6272[7]	1.8676
40	Isoprene	C_5H_8	(412.0)[1]	(558.4)[1]	0.6861	2.3519
41	Acetylene	C_2H_2	95.31	890.4	0.615[9]	0.8990
42	Benzene	C_6H_6	552.22	710.4	0.8844	2.6969
43	Toluene	C_7H_8	605.55	595.9	0.8718	3.1812

12.3 Physical Constants of Hydrocarbons, continued.

No.	Compound	Formula	Molecular Weight	Boiling Point at 14.696 psia (°F)	Vapor Pressure at 100 °F (psia)	Freezing Point at 14.696 psia (°F)
44	Ethylbenzene	C_8H_{10}	106.168	277.16	0.371	-138.91
45	o–Xylene	C_8H_{10}	106.168	291.97	0.264	-13.30
46	m–Xylene	C_8H_{10}	106.168	282.41	0.326	-54.12
47	p–Xylene	C_8H_{10}	106.168	281.05	0.342	55.86
48	Styrene	C_8H_8	104.152	293.29	(0.24)[1]	-23.10
49	Isopropylbenzene	C_9H_{12}	120.195	306.34	0.188	-140.82

No.	Compound	Formula	Critical Constants		Specific Gravity at 14.696 psia	
			Critical Temperature (°F)	Critical Pressure (psia)	Liquid [3,4] 60/60 °F	Gas at 60 °F (Air=1)[5]
44	Ethylbenzene	C_8H_{10}	651.24	523.5	0.8718	3.6655
45	o–Xylene	C_8H_{10}	675.0	541.4	0.8848	3.6655
46	m–Xylene	C_8H_{10}	651.02	513.6	0.8687	3.6655
47	p–Xylene	C_8H_{10}	649.6	509.2	0.8657	3.6655
48	Styrene	C_8H_8	706.0	580.0	0.9110	3.5959
49	Isopropylbenzene	C_9H_{12}	676.4	465.4	0.8663	4.1498

1. (   )–Estimated values.
2. At saturation pressure (triple point).
3. Air saturated hydrocarbons.
4. Absolute values from weights in vacuum.
5. Calculated values.
6. Apparent value for methane at 60 °F (15.5 °C).
7. Saturation pressure at 60 °F (15.5 °C).
8. Sublimation point.
9. Specific gravity, 119 °F/60 °F (sublimation point).

12.4 Specific Heat Ratio, *k*

Gas	Specific Heat Ratio, *k*	Gas	Specific Heat Ratio, *k*	Gas	Specific Heat Ratio, *k*	Gas	Specific Heat Ratio, *k*
Acetylene	1.38	Carbon Dioxide	1.29	0.6 Natural Gas	1.32	Steam[1]	1.33
Air	1.40	Ethane	1.25	Nitrogen	1.40		
Argon	1.67	Helium	1.66	Oxygen	1.40		
Butane	1.17	Hydrogen	1.40	Propane	1.21		
Carbon Monoxide	1.40	Methane	1.26	Propylene	1.15		

1. Use property tables if available for greater accuracy.

12.5 Physical Constants of Various Fluids

Fluid	Formula	Molecular Weight	Boiling Point (°F at 14.696 psia)	Vapor Pressure at 70 °F (psig)	Critical Temp. (°F)	Critical Pressure (psia)	Specific Gravity	
							Liquid (60/60 °F)	Gas
Acetic Acid	$HC_2H_3O_2$	60.05	245	–	–	–	1.05	–
Acetone	C_3H_6O	58.08	133	–	455	691	0.79	2.01
Air	N_2, O_2, other gases	28.97	-317	–	-221	547	0.86	1.0
Alcohol, Ethyl	C_2H_6O	46.07	173	2.3[1]	470	925	0.794	1.59
Alcohol, Methyl	CH_4O	32.04	148	4.63[1]	463	1174	0.796	1.11
Ammonia	NH_3	17.03	-28	114	270	1636	0.62	0.59
Ammonium Chloride[2]	NH_4Cl	–	–	–	–	–	1.07	–
Ammonium Hydroxide[2]	NH_4OH	–	–	–	–	–	0.91	–
Ammonium Sulfate[2]	$(NH_4)_2SO_4$	–	–	–	–	–	1.15	–
Aniline	C_6H_7N	93.12	365	–	798	770	1.02	–
Argon	A	39.94	-302	–	-188	705	1.65	1.38
Beer	–	–	–	–	–	–	1.01	–
Bromine	Br_2	159.84	138	–	575	–	2.93	5.52
Calcium Chloride[2]	$CaCl_2$	–	–	–	–	–	1.23	–
Carbon Dioxide	CO_2	44.01	-109	839	88	1072	0.801[1]	1.52
Carbon Disulfide	CS_2	76.1	115	–	–	–	1.29	2.63
Carbon Monoxide	CO	28.01	-314	–	-220	507	0.80	0.97
Carbon Tetrachloride	CCl_4	153.84	170	–	542	661	1.59	5.31
Chlorine	Cl_2	70.91	-30	85	291	1119	1.42	2.45
Chromic Acid	H_2CrO_4	118.03	–	–	–	–	1.21	–
Citric Acid	$C_6H_8O_7$	192.12	–	–	–	–	1.54	–
Copper Sulfate[2]	$CuSO_4$	–	–	–	–	–	1.17	–
Ether	$(C_2H_5)_2O$	74.12	34	–	–	–	0.74	2.55
Ferric Chloride[2]	$FeCl_3$	–	–	–	–	–	1.23	–
Fluorine	F_2	38.00	-305	300	1200	809	1.11	1.31
Formaldehyde	H_2CO	30.03	-6	–	–	–	0.82	1.08
Formic Acid	HCO_2H	46.03	214	–	–	–	1.23	–
Furfural	$C_5H_4O_2$	96.08	324	–	–	–	1.16	–

12.5 Physical Constants of Various Fluids, continued.

Fluid	Formula	Molecular Weight	Boiling Point (°F at 14.696 psia)	Vapor Pressure at 70 °F (psig)	Critical Temp. (°F)	Critical Pressure (psia)	Specific Gravity	
							Liquid (60/60 °F)	Gas
Glycerine	$C_3H_8O_3$	92.09	554	–	–	–	1.26	–
Glycol	$C_2H_6O_2$	62.07	387	–	–	–	1.11	–
Helium	He	4.003	-454	–	-450	33	0.18	0.14
Hydrochloric Acid	HCl	36.47	-115	–	–	–	1.64	–
Hydrofluoric Acid	HF	20.01	66	0.9	446	–	0.92	–
Hydrogen	H_2	2.016	-422	–	-400	188	0.07	0.07
Hydrogen Chloride	HCl	36.47	-115	613	125	1198	0.86	1.26
Hydrogen Sulfide	H_2S	34.07	-76	252	213	1307	0.79	1.17
Isopropyl Alcohol	C_3H_8O	60.09	180	–	–	–	0.78	2.08
Linseed Oil	–	–	538	–	–	–	0.93	–
Magnesium Chloride[2]	$MgCl_2$	–	–	–	–	–	1.22	–
Mercury	Hg	200.61	670	–	–	–	13.6	6.93
Methyl Bromide	CH_3Br	94.95	38	13	376	1226	1.73	3.27
Methyl Chloride	CH_3Cl	50.49	-11	59	290	969	0.99	1.74
Naphthalene	$C_{10}H_8$	128.16	424	–	–	–	1.14	4.43
Nitric Acid	HNO_3	63.02	187	–	–	–	1.5	–
Nitrogen	N_2	28.02	-320	–	-233	493	0.81	0.97
Oil, Vegetable	–	–	–	–	–	–	0.91-0.94	–
Oxygen	O_2	32	-297	–	-181	737	1.14	1.105
Phosgene	$COCl_2$	98.92	47	10.7	360	823	1.39	3.42
Phosphoric Acid	H_3PO_4	98.00	415	–	–	–	1.83	–
Potassium Carbonate[2]	K_2CO_3	–	–	–	–	–	1.24	–
Potassium Chloride[2]	KCl	–	–	–	–	–	1.16	–
Potassium Hydroxide[2]	KOH	–	–	–	–	–	1.24	–
Sodium Chloride[2]	NaCl	–	–	–	–	–	1.19	–
Sodium Hydroxide[2]	NaOH	–	–	–	–	–	1.27	–

12.5 Physical Constants of Various Fluids, continued.

Fluid	Formula	Molecular Weight	Boiling Point (°F at 14.696 psia)	Vapor Pressure at 70 °F (psig)	Critical Temp. (°F)	Critical Pressure (psia)	Specific Gravity	
							Liquid (60/60 °F)	Gas
Sodium Sulfate[2]	Na_2SO_4	–	–	–	–	–	1.24	–
Sodium Thiosulfate[2]	$Na_2S_2O_3$	–	–	–	–	–	1.23	–
Starch	$(C_6H_{10}O_5)x$	–	–	–	–	–	1.50	–
Sugar Solutions[2]	$C_{12}H_{22}0_{11}$	–	–	–	–	–	1.10	–
Sulfuric Acid	H_2SO_4	98.08	626	–	–	–	1.83	–
Sulfur Dioxide	SO_2	64.6	14	34.4	316	1145	1.39	2.21
Turpentine	–	–	320	–	–	–	0.87	–
Water	H_2O	18.016	212	0.9492[1]	706	3208	1.00	0.62
Zinc Chloride[2]	$ZnCl_2$	–	–	–	–	–	1.24	–
Zinc Sulfate[3]	$ZnSO_4$	–	–	–	–	–	1.31	–

1. Vapor pressure in psia at 100 °F (39 °C).
2. Aqueous solution – 25% by weight of compound.

12.6 Properties of Water

Temperature (°F)	Saturation Pressure (psi, Absolute)	Weight (lb/gallon)	Specific Gravity 60/60 °F	Conversion Factor[1] lb/hr to gal/min
32	0.0885	8.345	1.0013	0.00199
40	0.1217	8.345	1.0013	0.00199
50	0.1781	8.340	1.0007	0.00199
60	0.2653	8.334	1.0000	0.00199
70	0.3631	8.325	0.9989	0.00200
80	0.5069	8.314	0.9976	0.00200
90	0.6982	8.303	0.9963	0.00200
100	0.9492	8.289	0.9946	0.00201
110	1.2748	8.267	0.9919	0.00201
120	1.6924	8.253	0.9901	0.00201
130	2.2225	8.227	0.9872	0.00202
140	2.8886	8.207	0.9848	0.00203
150	3.718	8.182	0.9818	0.00203
160	4.741	8.156	0.9786	0.00204
170	5.992	8.127	0.9752	0.00205
180	7.510	8.098	0.9717	0.00205
190	9.339	8.068	0.9681	0.00206
200	11.526	8.039	0.9646	0.00207
210	14.123	8.005	0.9605	0.00208
212	14.696	7.996	0.9594	0.00208
220	17.186	7.972	0.9566	0.00209
240	24.969	7.901	0.9480	0.00210
260	35.429	7.822	0.9386	0.00211
280	49.203	7.746	0.9294	0.00215
300	67.013	7.662	0.9194	0.00217
350	134.63	7.432	0.8918	0.00224
400	247.31	7.172	0.8606	0.00232
450	422.6	6.892	0.8270	0.00241
500	680.8	6.553	0.7863	0.00254
550	1045.2	6.132	0.7358	0.00271
600	1542.9	5.664	0.6796	0.00294
700	3093.7	3.623	0.4347	0.00460

1. *Multiply flow in pounds per hour by the factor to get equivalent flow in gallons per minute. Weight per gallon is based on 7.48 gallons per cubic foot.*

12.7 Properties of Saturated Steam

Absolute Pressure		Vacuum (in Hg)	Temperature (°F)	Heat of the Liquid (BTU/lb)	Latent Heat of Evaporation (BTU/lb)	Total Heat of Steam (BTU/lb)	Specific Volume (ft^3/lb)
lb/in²	in Hg						
0.20	0.41	29.51	53.14	21.21	1063.8	1085.0	1526.0
0.25	0.51	29.41	59.30	27.36	1060.3	1087.7	1235.3
0.30	0.61	29.31	64.47	32.52	1057.4	1090.0	1039.5
0.35	0.71	29.21	68.93	36.97	1054.9	1091.9	898.5
0.40	0.81	29.11	72.86	40.89	1052.7	1093.6	791.9
0.45	0.92	29.00	76.38	44.41	1050.7	1095.1	708.5
0.50	1.02	28.90	79.58	47.60	1048.8	1096.4	641.4
0.60	1.22	28.70	85.21	53.21	1045.7	1098.9	540.0
0.70	1.43	28.49	90.08	58.07	1042.9	1101.0	466.9
0.80	1.63	28.29	94.38	62.36	1040.4	1102.8	411.7
0.90	1.83	28.09	98.24	66.21	1038.3	1104.5	368.4
1.0	2.04	27.88	101.74	69.70	1036.3	1106.0	333.6
1.2	2.44	27.48	107.92	75.87	1032.7	1108.6	280.9
1.4	2.85	27.07	113.26	81.20	1029.6	1110.8	243.0
1.6	3.26	26.66	117.99	85.91	1026.9	1112.8	214.3
1.8	3.66	26.26	122.23	90.14	1024.5	1114.6	191.8
2.0	4.07	25.85	126.08	93.99	1022.2	1116.2	173.73
2.2	4.48	25.44	129.62	97.52	1020.2	1117.7	158.85
2.4	4.89	25.03	132.89	100.79	1018.3	1119.1	146.38
2.6	5.29	24.63	135.94	103.83	1016.5	1120.3	135.78
2.8	5.70	24.22	138.79	106.68	1014.8	1121.5	126.65
3.0	6.11	23.81	141.48	109.37	1013.2	1122.6	118.71
3.5	7.13	22.79	147.57	115.46	1009.6	1125.1	102.72
4.0	8.14	21.78	152.97	120.86	1006.4	1127.3	90.63
4.5	9.16	20.76	157.83	125.71	1003.6	1129.3	81.16
5.0	10.18	19.74	162.24	130.13	1001.0	1131.1	73.52
5.5	11.20	18.72	166.30	134.19	998.5	1132.7	67.24
6.0	12.22	17.70	170.06	137.96	996.2	1134.2	61.98
6.5	13.23	16.69	173.56	141.47	994.1	1135.6	57.50
7.0	14.25	15.67	176.85	144.76	992.1	1136.9	53.64
7.5	15.27	14.65	179.94	147.86	990.2	1138.1	50.29
8.0	16.29	13.63	182.86	150.79	988.5	1139.3	47.34
8.5	17.31	12.61	185.64	153.57	986.8	1140.4	44.73
9.0	18.32	11.60	188.28	156.22	985.2	1141.4	42.40

12.7 Properties of Saturated Steam, continued.

Absolute Pressure		Vacuum (in Hg)	Temperature (°F)	Heat of the Liquid (BTU/lb)	Latent Heat of Evaporation (BTU/lb)	Total Heat of Steam (BTU/lb)	Specific Volume (ft^3/lb)
lb/in^2	in Hg						
9.5	19.34	10.58	190.80	158.75	983.6	1142.3	40.31
10.0	20.36	9.56	193.21	161.17	982.1	1143.3	38.42
11.0	22.40	7.52	197.75	165.73	979.3	1145.0	35.14
12.0	24.43	5.49	201.96	169.96	976.6	1146.6	32.40
13.0	26.47	3.45	205.88	173.91	974.2	1148.1	30.06
14.0	28.50	1.42	209.56	177.61	971.9	1149.5	28.04

Pressure (lb/in^2)		Temperature (°F)	Heat of the Liquid (BTU/lb)	Latent Heat of Evaporation (BTU/lb)	Total Heat of Steam (BTU/lb)	Specific Volume (ft^3/lb)
Absolute	Gage					
14.696	0.0	212.00	180.07	970.3	1150.4	26.80
15.0	0.3	213.03	181.11	969.7	1150.8	26.29
16.0	1.3	216.32	184.42	967.6	1152.0	24.75
17.0	2.3	219.44	187.56	965.5	1153.1	23.39
18.0	3.3	222.41	190.56	963.6	1154.2	22.17
19.0	4.3	225.24	193.42	961.9	1155.3	21.08
20.0	5.3	227.96	196.16	960.1	1156.3	20.089
21.0	6.3	230.57	198.79	958.4	1157.2	19.192
22.0	7.3	233.07	201.33	956.8	1158.1	18.375
23.0	8.3	235.49	203.78	955.2	1159.0	17.627
24.0	9.3	237.82	206.14	953.7	1159.8	16.938
25.0	10.3	240.07	208.42	952.1	1160.6	16.303
26.0	11.3	242.25	210.62	950.7	1161.3	15.715
27.0	12.3	244.36	212.75	949.3	1162.0	15.170
28.0	13.3	246.41	214.83	947.9	1162.7	14.663
29.0	14.3	248.40	216.86	946.5	1163.4	14.189
30.0	15.3	250.33	218.82	945.3	1164.1	13.746
31.0	16.3	252.22	220.73	944.0	1164.7	13.330
32.0	17.3	254.05	222.59	942.8	1165.4	12.940
33.0	18.3	255.84	224.41	941.6	1166.0	12.572
34.0	19.3	257.58	226.18	940.3	1166.5	12.226
35.0	20.3	259.28	227.91	939.2	1167.1	11.898
36.0	21.3	260.95	229.60	938.0	1167.6	11.588
37.0	22.3	262.57	231.26	936.9	1168.2	11.294

12.7 Properties of Saturated Steam, continued.

Pressure (lb/in²)		Temperature (°F)	Heat of the Liquid (BTU/lb)	Latent Heat of Evaporation (BTU/lb)	Total Heat of Steam (BTU/lb)	Specific Volume (ft³/lb)
Absolute	Gage					
38.0	23.3	264.16	232.89	935.8	1168.7	11.015
39.0	24.3	265.72	234.48	934.7	1169.2	10.750
40.0	25.3	267.25	236.03	933.7	1169.7	10.498
41.0	26.3	268.74	237.55	932.6	1170.2	10.258
42.0	27.3	270.21	239.04	931.6	1170.7	10.029
43.0	28.3	271.64	240.51	930.6	1171.1	9.810
44.0	29.3	273.05	241.95	929.6	1171.6	9.601
45.0	30.3	274.44	243.36	928.6	1172.0	9.401
46.0	31.3	275.80	244.75	927.7	1172.4	9.209
47.0	32.3	277.13	246.12	926.7	1172.9	9.025
48.0	33.3	278.45	247.47	925.8	1173.3	8.848
49.0	34.3	279.74	248.79	924.9	1173.7	8.678
50.0	35.3	281.01	250.09	924.0	1174.1	8.515
51.0	36.3	282.26	251.37	923.0	1174.4	8.359
52.0	37.3	283.49	252.63	922.2	1174.8	8.208
53.0	38.3	284.70	253.87	921.3	1175.2	8.062
54.0	39.3	285.90	255.09	920.5	1175.6	7.922
55.0	40.3	287.07	256.30	919.6	1175.9	7.787
56.0	41.3	288.23	257.50	918.8	1176.3	7.656
57.0	42.3	289.37	258.67	917.9	1176.6	7.529
58.0	43.3	290.50	259.82	917.1	1176.9	7.407
59.0	44.3	291.61	260.96	916.3	1177.3	7.289
60.0	45.3	292.71	262.09	915.5	1177.6	7.175
61.0	46.3	293.79	263.20	914.7	1177.9	7.064
62.0	47.3	294.85	264.30	913.9	1178.2	6.957
63.0	48.3	295.90	265.38	913.1	1178.5	6.853
64.0	49.3	296.94	266.45	912.3	1178.8	6.752
65.0	50.3	297.97	267.50	911.6	1179.1	6.655
66.0	51.3	298.99	268.55	910.8	1179.4	6.560
67.0	52.3	299.99	269.58	910.1	1179.7	6.468
68.0	53.3	300.98	270.60	909.4	1180.0	6.378
69.0	54.3	301.96	291.61	908.7	1180.3	6.291
70.0	55.3	302.92	272.61	907.9	1180.6	6.206
71.0	56.3	303.88	273.60	907.2	1180.8	6.124

12.7 Properties of Saturated Steam, continued.

Pressure (lb/in²)		Temperature (°F)	Heat of the Liquid (BTU/lb)	Latent Heat of Evaporation (BTU/lb)	Total Heat of Steam (BTU/lb)	Specific Volume (ft³/lb)
Absolute	Gage					
72.0	57.3	304.83	274.57	906.5	1181.1	6.044
73.0	58.3	305.76	275.54	905.8	1181.3	5.966
74.0	59.3	306.68	276.49	905.1	1181.6	5.890
75.0	60.3	307.60	277.43	904.5	1181.9	5.816
76.0	61.3	308.50	278.37	903.7	1182.1	5.743
77.0	62.3	309.40	279.30	903.1	1182.4	5.673
78.0	63.3	310.29	280.21	902.4	1182.6	5.604
79.0	64.3	311.16	281.12	901.7	1182.8	5.537
80.0	65.3	312.03	282.02	901.1	1183.1	5.472
81.0	66.3	312.89	282.91	900.4	1183.3	5.408
82.0	67.3	313.74	283.79	899.7	1183.5	5.346
83.0	68.3	314.59	284.66	899.1	1183.8	5.285
84.0	69.3	315.42	285.53	898.5	1184.0	5.226
85.0	70.3	316.25	286.39	897.8	1184.2	5.168
86.0	71.3	317.07	287.24	897.2	1184.4	5.111
87.0	72.3	317.88	288.08	896.5	1184.6	5.055
88.0	73.3	318.68	288.91	895.9	1184.8	5.001
89.0	74.3	319.48	289.74	895.3	1185.1	4.948
90.0	75.3	320.27	290.56	894.7	1185.3	4.896
91.0	76.3	321.06	291.38	894.1	1185.5	4.845
92.0	77.3	321.83	292.18	893.5	1185.7	4.796
93.0	78.3	322.60	292.98	892.9	1185.9	4.747
94.0	79.3	323.36	293.78	892.3	1186.1	4.699
95.0	80.3	324.12	294.56	891.7	1186.2	4.652
96.0	81.3	324.87	295.34	891.1	1186.4	4.606
97.0	82.3	325.61	296.12	890.5	1186.6	4.561
98.0	83.3	326.35	296.89	889.9	1186.8	4.517
99.0	84.3	327.08	297.65	889.4	1187.0	4.474
100.0	85.3	327.81	298.40	888.8	1187.2	4.432
101.0	86.3	328.53	299.15	888.2	1187.4	4.391
102.0	87.3	329.25	299.90	887.6	1187.5	4.350
103.0	88.3	329.96	300.64	887.1	1187.7	4.310
104.0	89.3	330.66	301.37	886.5	1187.9	4.271
105.0	90.3	331.36	302.10	886.0	1188.1	4.232
106.0	91.3	332.05	302.82	885.4	1188.2	4.194

12.7 Properties of Saturated Steam, continued.

Pressure (lb/in²)		Temperature (°F)	Heat of the Liquid (BTU/lb)	Latent Heat of Evaporation (BTU/lb)	Total Heat of Steam (BTU/lb)	Specific Volume (ft³/lb)
Absolute	Gage					
107.0	92.3	332.74	303.54	884.9	1188.4	4.157
108.0	93.3	333.42	304.26	884.3	1188.6	4.120
109.0	94.3	334.10	304.97	883.7	1188.7	4.084
110.0	95.3	334.77	305.66	883.2	1188.9	4.049
111.0	96.3	335.44	306.37	882.6	1189.0	4.015
112.0	97.3	336.11	307.06	882.1	1189.2	3.981
113.0	98.3	336.77	307.75	881.6	1189.4	3.947
114.0	99.3	337.42	308.43	881.1	1189.5	3.914
115.0	100.3	338.07	309.11	880.6	1189.7	3.882
116.0	101.3	338.72	309.79	880.0	1189.8	3.850
117.0	102.3	339.36	310.46	879.5	1190.0	3.819
118.0	103.3	339.99	311.12	879.0	1190.1	3.788
119.0	104.3	340.62	311.78	878.4	1190.2	3.758
120.0	105.3	341.25	312.44	877.9	1190.4	3.728
121.0	106.3	341.88	313.10	877.4	1190.5	3.699
122.0	107.3	342.50	313.75	876.9	1190.7	3.670
123.0	108.3	343.11	314.40	876.4	1190.8	3.642
124.0	109.3	343.72	315.04	875.9	1190.9	3.614
125.0	110.3	344.33	315.68	875.4	1191.1	3.587
126.0	111.3	344.94	316.31	874.9	1191.2	3.560
127.0	112.3	345.54	316.94	874.4	1191.3	3.533
128.0	113.3	346.13	317.57	873.9	1191.5	3.507
129.0	114.3	346.73	318.19	873.4	1191.6	3.481
130.0	115.3	347.32	318.81	872.9	1191.7	3.455
131.0	116.3	347.90	319.43	872.5	1191.9	3.430
132.0	117.3	348.48	320.04	872.0	1192.0	3.405
133.0	118.3	349.06	320.65	871.5	1192.1	3.381
134.0	119.3	349.64	321.25	871.0	1192.2	3.357
135.0	120.3	350.21	321.85	870.6	1192.4	3.333
136.0	121.3	350.78	322.45	870.1	1192.5	3.310
137.0	122.3	351.35	323.05	869.6	1192.6	3.287
138.0	123.3	351.91	323.64	869.1	1192.7	3.264
139.0	124.3	352.47	324.23	868.7	1192.9	3.242
140.0	125.3	353.02	324.82	868.2	1193.0	3.220
141.0	126.3	353.57	325.40	867.7	1193.1	3.198

12.7 Properties of Saturated Steam, continued.

Pressure (lb/in²)		Temperature (°F)	Heat of the Liquid (BTU/lb)	Latent Heat of Evaporation (BTU/lb)	Total Heat of Steam (BTU/lb)	Specific Volume (ft³/lb)
Absolute	Gage					
142.0	127.3	354.12	325.98	867.2	1193.2	3.177
143.0	128.3	354.67	326.56	866.7	1193.3	3.155
144.0	129.3	355.21	327.13	866.3	1193.4	3.134
145.0	130.3	355.76	327.70	865.8	1193.5	3.114
146.0	131.3	356.29	328.27	865.3	1193.6	3.094
147.0	132.3	356.83	328.83	864.9	1193.8	3.074
148.0	133.3	357.36	329.39	864.5	1193.9	3.054
149.0	134.3	357.89	329.95	864.0	1194.0	3.034
150.0	135.3	358.42	330.51	863.6	1194.1	3.015
152.0	137.3	359.46	331.61	862.7	1194.3	2.977
154.0	139.3	360.49	332.70	861.8	1194.5	2.940
156.0	141.3	361.52	333.79	860.9	1194.7	2.904
158.0	143.3	362.53	334.86	860.0	1194.9	2.869
160.0	145.3	363.53	335.93	859.2	1195.1	2.834
162.0	147.3	364.53	336.98	858.3	1195.3	2.801
164.0	149.3	365.51	338.02	857.5	1195.5	2.768
166.0	151.3	366.48	339.05	856.6	1195.7	2.736
168.0	153.3	367.45	340.07	855.7	1195.8	2.705
170.0	155.3	368.41	341.09	854.9	1196.0	2.675
172.0	157.3	369.35	342.10	854.1	1196.2	2.645
174.0	159.3	370.29	343.10	853.3	1196.4	2.616
176.0	161.3	371.22	344.09	852.4	1196.5	2.587
178.0	163.3	372.14	345.06	851.6	1196.7	2.559
180.0	165.3	373.06	346.03	850.8	1196.9	2.532
182.0	167.3	373.96	347.00	850.0	1197.0	2.505
184.0	169.3	374.86	347.96	849.2	1197.2	2.479
186.0	171.3	375.75	348.92	848.4	1197.3	2.454
188.0	173.3	376.64	349.86	847.6	1197.5	2.429
190.0	175.3	377.51	350.79	846.8	1197.6	2.404
192.0	177.3	378.38	351.72	846.1	1197.8	2.380
194.0	179.3	379.24	352.64	845.3	1197.9	2.356
196.0	181.3	380.10	353.55	844.5	1198.1	2.333
198.0	183.3	380.95	354.46	843.7	1198.2	2.310
200.0	185.3	381.79	355.36	843.0	1198.4	2.288

12.7 Properties of Saturated Steam, continued.

Pressure (lb/in²)		Temperature (°F)	Heat of the Liquid (BTU/lb)	Latent Heat of Evaporation (BTU/lb)	Total Heat of Steam (BTU/lb)	Specific Volume (ft³/lb)
Absolute	Gage					
205.0	190.3	383.86	357.58	841.1	1198.7	2.234
210.0	195.3	385.90	359.77	839.2	1199.0	2.183
215.0	200.3	387.89	361.91	837.4	1199.3	2.134
220.0	205.3	389.86	364.02	835.6	1199.6	2.087
225.0	210.3	391.79	366.09	833.8	1199.9	2.0422
230.0	215.3	393.68	368.13	832.0	1200.1	1.9992
235.0	220.3	395.54	370.14	830.3	1200.4	1.9579
240.0	225.3	397.37	372.12	828.5	1200.6	1.9183
245.0	230.3	399.18	374.08	826.8	1200.9	1.8803
250.0	235.3	400.95	376.00	825.1	1201.1	1.8438
255.0	240.3	402.70	377.89	823.4	1201.3	1.8086
260.0	245.3	404.42	379.76	821.8	1201.5	1.7748
265.0	250.3	406.11	381.60	820.1	1201.7	1.7422
270.0	255.3	407.78	383.42	818.5	1201.9	1.7107
275.0	260.3	409.43	385.21	816.9	1202.1	1.6804
280.0	265.3	411.05	386.98	815.3	1202.3	1.6511
285.0	270.3	412.65	388.73	813.7	1202.4	1.6228
290.0	275.3	414.23	390.46	812.1	1202.6	1.5954
295.0	280.3	415.79	392.16	810.5	1202.7	1.5689
300.0	285.3	417.33	393.84	809.0	1202.8	1.5433
320.0	305.3	423.29	400.39	803.0	1203.4	1.4485
340.0	325.3	428.97	406.66	797.1	1203.7	1.3645
360.0	345.3	434.40	412.67	791.4	1204.1	1.2895
380.0	365.3	439.60	418.45	785.8	1204.3	1.2222
400.0	385.3	444.59	424.0	780.5	1204.5	1.1613
420.0	405.3	449.39	429.4	775.2	1204.6	1.1061
440.0	425.3	454.02	434.6	770.0	1204.6	1.0556
460.0	445.3	458.50	439.7	764.9	1204.6	1.0094
480.0	465.3	462.82	444.6	759.9	1204.5	0.9670
500.0	485.3	467.01	449.4	755.0	1204.4	0.9278
520.0	505.3	471.07	454.1	750.1	1204.2	0.8915
540.0	525.3	475.01	458.6	745.4	1204.0	0.8578
560.0	545.3	478.85	463.0	740.8	1203.8	0.8265
580.0	565.3	482.58	467.4	736.1	1203.5	0.7973

12.7 Properties of Saturated Steam, continued.

Pressure (lb/in²)		Temperature (°F)	Heat of the Liquid (BTU/lb)	Latent Heat of Evaporation (BTU/lb)	Total Heat of Steam (BTU/lb)	Specific Volume (ft³/lb)
Absolute	Gage					
600.0	585.3	486.21	471.6	731.6	1203.2	0.7698
620.0	605.3	489.75	475.7	727.2	1202.9	0.7440
640.0	625.3	493.21	479.8	722.7	1202.5	0.7198
660.0	645.3	496.58	483.8	718.3	1202.1	0.6971
680.0	665.3	499.88	487.7	714.0	1201.7	0.6757
700.0	685.3	503.10	491.5	709.7	1201.2	0.6554
720.0	705.3	506.25	495.3	705.4	1200.7	0.6362
740.0	725.3	509.34	499.0	701.2	1200.2	0.6180
760.0	745.3	512.36	502.6	697.1	1199.7	0.6007
780.0	765.3	515.33	506.2	692.9	1199.1	0.5843
800.0	785.3	518.23	509.7	688.9	1198.6	0.5687
820.0	805.3	521.08	513.2	684.8	1198.0	0.5538
840.0	825.3	523.88	516.6	680.8	1197.4	0.5396
860.0	845.3	526.63	520.0	676.8	1196.8	0.5260
880.0	865.3	529.33	523.3	672.8	1196.1	0.5130
900.0	885.3	531.98	526.6	668.8	1195.4	0.5006
920.0	905.3	534.59	529.8	664.9	1194.7	0.4886
940.0	925.3	537.16	533.0	661.0	1194.0	0.4772
960.0	945.3	539.68	536.2	657.1	1193.3	0.4663
980.0	965.3	542.17	539.3	653.3	1192.6	0.4557
1000.0	985.3	544.61	542.4	649.4	1191.8	0.4456
1050.0	1035.3	550.57	550.0	639.9	1189.9	0.4218
1100.0	1085.3	556.31	557.4	630.4	1187.8	0.4001
1150.0	1135.3	561.86	564.6	621.0	1185.6	0.3802
1200.0	1185.3	567.22	571.7	611.7	1183.4	0.3619
1250.0	1235.3	572.42	578.6	602.4	1181.0	0.3450
1300.0	1285.3	577.46	585.4	593.2	1178.6	0.3293
1350.0	1335.3	582.35	592.1	584.0	1176.1	0.3148
1400.0	1385.3	587.10	598.7	574.7	1173.4	0.3012
1450.0	1435.3	591.73	605.2	565.5	1170.7	0.2884
1500.0	1485.3	596.23	611.6	556.3	1167.9	0.2765
1600.0	1585.3	604.90	624.1	538.0	1162.1	0.2548
1700.0	1685.3	613.15	636.3	519.6	1155.9	0.2354
1800.0	1785.3	621.03	648.3	501.1	1149.4	0.2179

12.7 Properties of Saturated Steam, continued.

Pressure (lb/in²)		Temperature (°F)	Heat of the Liquid (BTU/lb)	Latent Heat of Evaporation (BTU/lb)	Total Heat of Steam (BTU/lb)	Specific Volume (ft^3/lb)
Absolute	Gage					
1900.0	1885.3	628.58	660.1	482.4	1142.4	0.2021
2000.0	1985.3	635.82	671.7	463.4	1135.1	0.1878
2100.0	2085.3	642.77	683.3	444.1	1127.4	0.1746
2200.0	2185.3	649.46	694.8	424.4	1119.2	0.1625
2300.0	2285.3	655.91	706.5	403.9	1110.4	0.1513
2400.0	2385.3	662.12	718.4	382.7	1101.1	0.1407
2500.0	2485.3	668.13	730.6	360.5	1091.1	0.1307
2600.0	2585.3	673.94	743.0	337.2	1080.2	0.1213
2700.0	2685.3	679.55	756.2	312.1	1068.3	0.1123
2800.0	2785.3	684.99	770.1	284.7	1054.8	0.1035
2900.0	2885.3	690.26	785.4	253.6	1039.0	0.0947
3000.0	2985.3	695.36	802.5	217.8	1020.3	0.0858
3100.0	3085.3	700.31	825.0	168.1	993.1	0.0753
3200.0	3185.3	705.11	872.4	62.0	934.4	0.0580
3206.2	3191.5	705.40	902.7	0.0	902.7	0.0503

12.8 Properties of Superheated Steam

v_f = specific volume, ft³/lb$_m$; h_v = Enthalpy, BTU/lb

Pressure (psi)		Saturated Temperature (°F)	v_f, h_v	Temperature (°F)					
Absolute	Gage			360	400	440	480	500	600
14.696	0.0	212.00	v_f h_v	33.03 1221.1	34.68 1239.9	36.32 1258.8	37.96 1277.6	38.78 1287.1	42.86 1334.8
20.0	5.3	227.96	v_f h_v	24.21 1220.3	25.43 1239.2	26.65 1258.2	27.86 1277.1	28.46 1286.6	31.47 1334.4
30.0	15.3	250.33	v_f h_v	16.072 1218.6	16.897 1237.9	17.714 1257.0	18.528 1276.2	18.933 1285.7	20.95 1333.8
40.0	25.3	267.25	v_f h_v	12.001 1216.9	12.628 1236.5	13.247 1255.9	13.862 1275.2	14.168 1284.8	15.688 1333.1
50.0	35.3	281.01	v_f h_v	9.557 1215.2	10.065 1235.1	10.567 1254.7	11.062 1274.2	11.309 1283.9	12.532 1332.5

Pressure (psi)		Saturated Temperature (°F)	v_f, h_v	Temperature (°F)				
Absolute	Gage			700	800	900	1000	1200
14.696	0.0	212.00	v_f h_v	46.94 1383.2	51.00 1432.3	55.07 1482.3	59.13 1533.1	67.25 1637.5
20.0	5.3	227.96	v_f h_v	34.47 1382.9	37.46 1432.1	40.45 1482.1	43.44 1533.0	49.41 1637.4
30.0	15.3	250.33	v_f h_v	22.96 1382.4	24.96 1431.7	26.95 1481.8	28.95 1532.7	32.93 1637.2
40.0	25.3	267.25	v_f h_v	17.198 1381.9	18.702 1431.3	20.20 1481.4	21.70 1532.4	24.69 1637.0
50.0	35.3	281.01	v_f h_v	13.744 1381.4	14.950 1430.9	16.152 1481.1	17.352 1532.1	19.747 1636.8

12.8 Properties of Superheated Steam, continued.

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)					
Absolute	Gage			360	400	440	480	500	600
60.0	45.3	292.71	v_f h_v	7.927 1213.4	8.357 1233.	8.779 1253.5	9.196 1273.2	9.403 1283.0	10.427 1331.8
70.0	55.3	302.92	v_f h_v	6.762 1211.5	7.136 1232.1	7.502 1252.3	7.863 1272.2	8.041 1282.0	8.924 1331.1
80.0	65.3	312.03	v_f h_v	5.888 1209.7	6.220 1230.7	6.544 1251.1	6.862 1271.1	7.020 1281.1	7.797 1330.5
90.0	75.3	320.27	v_f h_v	5.208 1207.7	5.508 1229.1	5.799 1249.8	6.084 1270.1	6.225 1280.1	6.920 1329.8
100.0	85.3	327.81	v_f h_v	4.663 1205.7	4.937 1227.6	5.202 1248.6	5.462 1269.0	5.589 1279.1	6.218 1329.1
120.0	105.3	341.25	v_f h_v	3.844 1201.6	4.081 1224.4	4.307 1246.0	4.527 1266.90	4.636 1277.2	5.165 1327.7
140.0	125.3	353.02	v_f h_v	3.258 1197.3	3.468 1221.1	3.667 1243.3	3.860 1264.7	3.954 1275.2	4.413 1326.4
160.0	145.3	363.53	v_f h_v	– –	3.008 1217.6	3.187 1240.6	3.359 1262.4	3.443 1273.1	3.849 1325.0
180.0	165.3	373.06	v_f h_v	– –	2.649 1214.0	2.813 1237.8	2.969 1260.2	3.044 1271.0	3.411 1323.5

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)				
Absolute	Gage			700	800	900	1000	1200
60.0	45.3	292.71	v_f h_v	11.441 1380.9	12.449 1430.5	13.452 1480.8	14.454 1531.9	16.451 1636.6
70.0	55.3	302.92	v_f h_v	9.796 1380.4	10.662 1430.1	11.524 1480.5	12.383 1531.6	14.097 1636.3
80.0	65.3	312.03	v_f h_v	8.562 1379.9	9.322 1429.7	10.077 1480.1	10.830 1531.3	12.332 1636.2
90.0	75.3	320.27	v_f h_v	7.603 1379.4	8.279 1429.3	8.952 1479.8	9.623 1531.0	10.959 1635.9
100.0	85.3	327.81	v_f h_v	6.835 1378.9	7.446 1428.9	8.052 1479.5	8.656 1530.8	9.860 1635.7
120.0	105.3	341.25	v_f h_v	5.683 1377.8	6.195 1428.1	6.702 1478.8	7.207 1530.2	8.212 1635.3
140.0	125.3	353.02	v_f h_v	4.861 1376.8	5.301 1427.3	5.738 1478.2	6.172 1529.7	7.035 1634.9
160.0	145.3	363.53	v_f h_v	4.244 1375.7	4.631 1426.4	5.015 1477.5	5.396 1529.1	6.152 1634.5
180.0	165.3	373.06	v_f h_v	3.764 1374.7	4.110 1425.6	4.452 1476.8	4.792 1528.6	5.466 1634.1

12.8 Properties of Superheated Steam, continued.

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)					
Absolute	Gage			360	400	440	480	500	600
200.0	185.3	381.79	v_f h_v	– –	2.361 1210.3	2.513 1234.9	2.656 1257.8	2.726 1268.9	3.060 1322.1
220.0	205.3	389.86	v_f h_v	– –	2.125 1206.5	2.267 1231.9	2.400 1255.4	2.465 1266.7	2.772 1320.7
240.0	225.3	397.37	v_f h_v	– –	1.9276 1202.5	2.062 1228.8	2.187 1253.0	2.247 1264.5	2.533 1319.2
260.0	245.3	404.42	v_f h_v	– –	– –	1.8882 1225.7	2.006 1250.5	2.063 1262.3	2.330 1317.7
280.0	265.3	411.05	v_f h_v	– –	– –	1.7388 1222.4	1.8512 1247.9	1.9047 1260.0	2.156 1316.2
300.0	285.3	417.33	v_f h_v	– –	– –	1.6090 1219.1	1.7165 1245.3	1.7675 1257.6	2.005 1314.7
320.0	305.3	423.29	v_f h_v	– –	– –	1.4950 1215.6	1.5985 1242.6	1.6472 1255.2	1.8734 1313.2
340.0	325.3	428.97	v_f h_v	– –	– –	1.3941 1212.1	1.4941 1239.9	1.5410 1252.8	1.7569 1311.6
360.0	345.3	434.40	v_f h_v	– –	– –	1.3041 1208.4	1.4012 1237.1	1.4464 1250.3	1.6533 1310.1

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)				
Absolute	Gage			700	800	900	1000	1200
200.0	185.3	381.79	v_f h_v	3.380 1373.6	3.693 1424.8	4.002 1476.2	4.309 1528.0	4.917 1633.7
220.0	205.3	389.86	v_f h_v	3.066 1372.6	3.352 1424.0	3.634 1475.5	3.913 1527.5	4.467 1633.3
240.0	225.3	397.37	v_f h_v	2.804 1371.5	3.068 1423.2	3.327 1474.8	3.584 1526.9	4.093 1632.9
260.0	245.3	404.42	v_f h_v	2.582 1370.4	2.827 1422.3	3.067 1474.2	3.305 1526.3	3.776 1632.5
280.0	265.3	411.05	v_f h_v	2.392 1369.4	2.621 1421.5	2.845 1473.5	3.066 1525.8	3.504 1632.1
300.0	285.3	417.33	v_f h_v	2.227 1368.3	2.442 1420.6	2.652 1472.8	2.859 1525.2	3.269 1631.7
320.0	305.3	423.29	v_f h_v	2.083 1367.2	2.285 1419.8	2.483 1472.1	2.678 1524.7	3.063 1631.3
340.0	325.3	428.97	v_f h_v	1.9562 1366.1	2.147 1419.0	2.334 1471.5	2.518 1524.1	2.881 1630.9
360.0	345.3	434.40	v_f h_v	1.8431 1365.0	2.025 1418.1	2.202 1470.8	2.376 1523.5	2.719 1630.5

12.8 Properties of Superheated Steam, continued.

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)					
Absolute	Gage			500	540	600	640	660	700
380.0	365.3	439.60	v_f h_v	1.3616 1247.7	1.444 1273.1	1.5605 1308.5	1.6345 1331.0	1.6707 1342.0	1.7419 1363.8
400.0	385.3	444.59	v_f h_v	1.2851 1245.1	1.3652 1271.0	1.4770 1306.9	1.5480 1329.6	1.5827 1340.8	1.6508 1362.7
420.0	405.3	449.39	v_f h_v	1.2158 1242.5	1.2935 1268.9	1.4014 1305.3	1.4697 1328.3	1.5030 1339.5	1.5684 1361.6
440.0	425.3	454.02	v_f h_v	1.1526 1239.8	1.2282 1266.7	1.3327 1303.6	1.3984 1326.9	1.4306 1338.2	1.4934 1360.4
460.0	445.3	458.50	v_f h_v	1.0948 1237.0	1.1685 1264.5	1.2698 1302.0	1.3334 1325.4	1.3644 1336.9	1.4250 1359.3
480.0	465.3	462.82	v_f h_v	1.0417 1234.2	1.1138 1262.3	1.2122 1300.3	1.2737 1324.0	1.3038 1335.6	1.3622 1358.2
500.0	485.3	467.01	v_f h_v	0.9927 1231.3	1.0633 1260.0	1.1591 1298.6	1.2188 1322.6	1.2478 1334.2	1.3044 1357.0
520.0	505.3	471.07	v_f h_v	0.9473 1228.3	1.0166 1257.7	1.1101 1296.9	1.1681 1321.1	1.1962 1332.9	1.2511 1355.8
540.0	525.3	475.01	v_f h_v	0.9052 1225.3	0.9733 1255.4	1.0646 1295.2	1.1211 1319.7	1.1485 1331.5	1.2017 1354.6

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)				
Absolute	Gage			740	800	900	1000	1200
380.0	365.3	439.60	v_f h_v	1.8118 1385.3	1.9149 1417.3	2.083 1470.1	2.249 1523.0	2.575 1630.0
400.0	385.3	444.59	v_f h_v	1.7177 1384.3	1.8161 1416.4	1.9767 1469.4	2.134 1522.4	2.445 1629.6
420.0	405.3	449.39	v_f h_v	1.6324 1383.3	1.7267 1415.5	1.8802 1468.7	2.031 1521.9	2.327 1629.2
440.0	425.3	454.02	v_f h_v	1.5549 1382.3	1.6454 1414.7	1.7925 1468.1	1.9368 1521.3	2.220 1628.8
460.0	445.3	458.50	v_f h_v	1.4842 1381.3	1.5711 1413.8	1.7124 1467.4	1.8508 1520.7	2.122 1628.4
480.0	465.3	462.82	v_f h_v	1.4193 1380.3	1.5031 1412.9	1.6390 1466.7	1.7720 1520.2	2.033 1628.0
500.0	485.3	467.01	v_f h_v	1.3596 1379.3	1.4405 1412.1	1.5715 1466.0	1.6996 1519.6	1.9504 1627.6
520.0	505.3	471.07	v_f h_v	1.3045 1378.2	1.3826 1411.2	1.5091 1465.3	1.6326 1519.0	1.8743 1627.2
540.0	525.3	475.01	v_f h_v	1.2535 1377.2	1.3291 1410.3	1.4514 1464.6	1.5707 1518.5	1.8039 1626.8

12.8 Properties of Superheated Steam, continued.

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)					
Absolute	Gage			500	540	600	640	660	700
560.0	545.3	478.85	v_f h_v	0.8659 1222.2	0.9330 1253.0	1.0224 1293.4	1.0775 1318.2	1.1041 1330.2	1.1558 1353.5
580.0	565.3	482.58	v_f h_v	0.8291 1219.0	0.8954 1250.5	0.9830 1291.7	1.0368 1316.7	1.0627 1328.8	1.1331 1352.3
600.0	585.3	486.21	v_f h_v	0.7947 1215.7	0.8602 1248.1	0.9463 1289.9	0.9988 1315.2	1.0241 1327.4	1.0732 1351.1
620.0	605.3	489.75	v_f h_v	0.7624 1212.4	0.8272 1245.5	0.9118 1288.1	0.9633 1313.7	0.9880 1326.0	1.0358 1349.9
640.0	625.3	493.21	v_f h_v	0.7319 1209.0	0.7963 1243.0	0.8795 1286.2	0.9299 1312.2	0.9541 1324.6	1.0008 1348.6
660.0	645.3	496.58	v_f h_v	0.7032 1205.4	0.7670 1240.4	0.8491 1284.4	0.8985 1310.6	0.9222 1323.2	0.9679 1347.4
680.0	665.3	499.88	v_f h_v	0.6759 1201.8	0.7395 1237.7	0.8205 1282.5	0.8690 1309.1	0.8922 1321.7	0.9369 1346.2
700.0	685.3	503.10	v_f h_v	– –	0.7134 1235.0	0.7934 1280.6	0.8411 1307.5	0.8639 1320.3	0.9077 1345.0
750.0	735.3	510.86	v_f h_v	– –	0.6540 1227.9	0.7319 1275.7	0.7778 1303.5	0.7996 1316.6	0.8414 1341.8

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)				
Absolute	Gage			740	800	900	1000	1200
560.0	545.3	478.85	v_f h_v	1.2060 1376.1	1.2794 1409.4	1.3978 1463.9	1.5132 1517.9	1.7385 1626.4
580.0	565.3	482.58	v_f h_v	1.1619 1375.1	1.2331 1408.6	1.3479 1463.2	1.4596 1517.3	1.6776 1626.0
600.0	585.3	486.21	v_f h_v	1.1207 1374.0	1.1899 1407.7	1.3013 1462.5	1.4096 1516.7	1.6208 1625.5
620.0	605.3	489.75	v_f h_v	1.0821 1373.0	1.1494 1406.8	1.2577 1461.8	1.3628 1516.2	1.5676 1625.1
640.0	625.3	493.21	v_f h_v	1.0459 1371.9	1.1115 1405.9	1.2168 1461.1	1.3190 1515.6	1.5178 1624.7
660.0	645.3	496.58	v_f h_v	1.0119 1370.8	1.0759 1405.0	1.1784 1460.4	1.2778 1515.0	1.4709 1624.3
680.0	665.3	499.88	v_f h_v	0.9800 1369.8	1.0424 1404.1	1.1423 1459.7	1.2390 1514.5	1.4269 1623.9
700.0	685.3	503.10	v_f h_v	0.9498 1368.7	1.0108 1403.2	1.1082 1459.0	1.2024 1513.9	1.3853 1623.5
750.0	735.3	510.86	v_f h_v	0.8813 1366.0	0.9391 1400.9	1.0310 1457.2	1.1196 1512.4	1.2912 1622.4

12.8 Properties of Superheated Steam, continued.

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)					
Absolute	Gage			500	540	600	640	660	700
800.0	785.3	518.23	v_f h_v	– –	0.6015 1220.5	0.6779 1270.7	0.7223 1299.4	0.7433 1312.9	0.7833 1338.6
850.0	835.3	525.26	v_f h_v	– –	0.5546 1212.7	0.6301 1265.5	0.6732 1295.2	0.6934 1309.0	0.7320 1335.4
900.0	885.3	531.98	v_f h_v	– –	0.5124 1204.4	0.5873 1260.1	0.6294 1290.9	0.6491 1305.1	0.6863 1332.1
950.0	935.3	538.42	v_f h_v	– –	0.4740 1195.5	0.5489 1254.6	0.5901 1286.4	0.6092 1301.1	0.6453 1328.7
1000.0	985.3	544.61	v_f h_v	– –	– –	0.5140 1248.8	0.5546 1281.9	0.5733 1297.0	0.6084 1325.3

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)				
Absolute	Gage			740	800	900	1000	1200
800.0	785.3	518.23	v_f h_v	0.8215 1363.2	0.8763 1398.6	0.9633 1455.4	1.0470 1511.0	1.2088 1621.4
850.0	835.3	525.26	v_f h_v	0.7685 1360.4	0.8209 1396.3	0.9037 1453.6	0.9830 1509.5	1.1360 1620.4
900.0	885.3	531.98	v_f h_v	0.7215 1357.5	0.7716 1393.9	0.8506 1451.8	0.9262 1508.1	1.0714 1619.3
950.0	935.3	538.42	v_f h_v	0.6793 1354.7	0.7275 1391.6	0.8031 1450.0	0.8753 1506.6	1.0136 1618.3
1000.0	985.3	544.61	v_f h_v	0.6413 1351.7	0.6878 1389.2	0.7604 1448.2	0.8294 1505.1	0.9615 1617.3

12.8 Properties of Superheated Steam, continued.

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)					
Absolute	Gage			660	700	740	760	780	800
1100.0	1085.3	556.31	v_f h_v	0.5110 1288.5	0.5445 1318.3	0.5755 1345.8	0.5904 1358.9	0.6049 1371.7	0.6191 1384.3
1200.0	1185.3	567.22	v_f h_v	0.4586 1279.6	0.4909 1311.0	0.5206 1339.6	0.5347 1353.2	0.5484 1366.4	0.5617 1379.3
1300.0	1285.3	577.46	v_f h_v	0.4139 1270.2	0.4454 1303.4	0.4739 1333.3	0.4874 1347.3	0.5004 1361.0	0.5131 1374.3
1400.0	1385.3	587.10	v_f h_v	0.3753 1260.3	0.4062 1295.5	0.4338 1326.7	0.4468 1341.3	0.4593 1355.4	0.4714 1369.1
1500.0	1485.3	596.23	v_f h_v	0.3413 1249.8	0.3719 1287.2	0.3989 1320.0	0.4114 1335.2	0.4235 1349.7	0.4352 1363.8
1600.0	1585.3	604.90	v_f h_v	0.3112 1238.7	0.3417 1278.7	0.3682 1313.0	0.3804 1328.8	0.3921 1343.9	0.4034 1358.4
1700.0	1685.3	613.15	v_f h_v	0.2842 1226.8	0.3148 1269.7	0.3410 1305.8	0.3529 1322.3	0.3643 1337.9	0.3753 1352.9
1800.0	1785.3	621.03	v_f h_v	0.2597 1214.0	0.2907 1260.3	0.3166 1298.4	0.3284 1315.5	0.3395 1331.8	0.3502 1347.2
1900.0	1885.3	628.58	v_f h_v	0.2371 1200.2	0.2688 1250.4	0.2947 1290.6	0.3063 1308.6	0.3173 1325.4	0.3277 1341.5

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)				
Absolute	Gage			860	900	1000	1100	1200
1100.0	1085.3	556.31	v_f h_v	0.6601 1420.8	0.6866 1444.5	0.7503 1502.2	0.8177 1558.8	0.8716 1615.2
1200.0	1185.3	567.22	v_f h_v	0.6003 1416.7	0.6250 1440.7	0.6843 1499.2	0.7412 1556.4	07967 1613.1
1300.0	1285.3	577.46	v_f h_v	0.5496 1412.5	0.5728 1437.0	0.6284 1496.2	0.6816 1553.9	0.7333 1611.0
1400.0	1385.3	587.10	v_f h_v	0.5061 1408.2	0.5281 1433.1	0.5805 1493.2	0.6305 1551.4	0.6789 1608.9
1500.0	1485.3	596.23	v_f h_v	0.4684 1403.9	0.4893 1429.3	0.5390 1490.1	0.5862 1548.9	0.6318 1606.8
1600.0	1585.3	604.90	v_f h_v	0.4353 1399.5	0.4553 1425.3	0.5027 1487.0	0.5474 1546.4	0.5906 1604.6
1700.0	1685.3	613.15	v_f h_v	0.4061 1395.0	0.4253 1421.4	0.4706 1484.0	0.5132 1543.8	0.5542 1602.5
1800.0	1785.3	621.03	v_f h_v	0.3801 1390.4	0.3986 1417.4	0.4421 1480.8	0.4828 1541.3	0.5218 1600.4
1900.0	1885.3	628.58	v_f h_v	0.3568 1385.8	0.3747 1413.3	0.4165 1477.7	0.4556 1538.8	0.4929 1598.2

12.8 Properties of Superheated Steam, continued.

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)					
Absolute	Gage			660	700	740	760	780	800
2000.0	1985.3	635.82	v_f h_v	0.2161 1184.9	0.2489 1240.0	0.2748 1282.6	0.2863 1301.4	0.2972 1319.0	0.3074 1335.5
2100.0	2085.3	642.77	v_f h_v	0.1962 1167.7	0.2306 1229.0	0.2567 1274.3	0.2682 1294.0	0.2789 1312.3	0.2890 1329.5
2200.0	2185.3	649.46	v_f h_v	0.1768 1147.8	0.2135 1217.4	0.2400 1265.7	0.2514 1286.3	0.2621 1305.4	0.2721 1323.3
2300.0	2285.3	655.91	v_f h_v	0.1575 1123.8	0.1978 1204.9	0.2247 1256.7	0.2362 1278.4	0.2468 1298.4	0.2567 1316.9
2400.0	2385.3	662.12	v_f h_v	– –	0.1828 1191.5	0.2105 1247.3	0.2221 1270.2	0.2327 1291.1	0.2425 1310.3
2500.0	2485.3	668.13	v_f h_v	– –	0.1686 1176.8	0.1973 1237.6	0.2090 1261.8	0.2196 1283.6	0.2294 1303.6
2600.0	2585.3	673.94	v_f h_v	– –	0.1549 1160.6	0.1849 1227.3	0.1967 1252.9	0.2074 1275.8	0.2172 1296.8
2700.0	2685.3	679.55	v_f h_v	– –	0.1415 1142.5	0.1732 1216.5	0.1853 1243.8	0.1960 1267.9	0.2059 1289.7
2800.0	2785.3	684.99	v_f h_v	– –	0.1281 1121.4	0.1622 1205.1	0.1745 1234.2	0.1854 1259.6	0.1953 1282.4

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)				
Absolute	Gage			860	900	1000	1100	1200
2000.0	1985.3	635.82	v_f h_v	0.3358 1381.2	0.3532 1409.2	0.3935 1474.5	0.4311 1536.2	0.4668 1596.1
2100.0	2085.3	642.77	v_f h_v	0.3167 1376.4	0.3337 1405.0	0.3727 1471.4	0.4089 1533.6	0.4433 1593.9
2200.0	2185.3	649.46	v_f h_v	0.2994 1371.5	0.3159 1400.8	0.3538 1468.2	0.3837 1531.1	0.4218 1591.8
2300.0	2285.3	655.91	v_f h_v	0.2835 1366.6	0.2997 1396.5	0.3365 1464.9	0.3703 1528.5	0.4023 1589.6
2400.0	2385.3	662.12	v_f h_v	0.2689 1361.6	0.2848 1392.2	0.3207 1461.7	0.3534 1525.9	0.3843 1587.4
2500.0	2485.3	668.13	v_f h_v	0.2555 1356.5	0.2710 1387.8	0.3061 1458.4	0.3379 1523.2	0.3678 1585.3
2600.0	2585.3	673.94	v_f h_v	0.2431 1351.4	0.2584 1383.4	0.2926 1455.1	0.3236 1520.6	0.3526 1583.1
2700.0	2685.3	679.55	v_f h_v	0.2315 1346.1	0.2466 1378.9	0.2801 1451.8	0.3103 1518.0	0.3385 1580.9
2800.0	2785.3	684.99	v_f h_v	0.2208 1340.8	0.2356 1374.3	0.2685 1448.5	0.2979 1515.4	0.3254 1578.7

12.8 Properties of Superheated Steam, continued.

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)					
Absolute	Gage			660	700	740	760	780	800
2900.0	2885.3	690.26	v_f h_v	– –	0.1143 1095.9	0.1517 1193.0	0.1644 1224.3	0.1754 1251.1	0.1853 1274.9
3000.0	2985.3	695.36	v_f h_v	– –	0.0984 1060.7	0.1416 1180.1	0.1548 1213.8	0.1660 1242.2	0.1760 1267.2
3100.0	3085.3	700.31	v_f h_v	– –	– –	0.1320 1166.2	0.1456 1202.9	0.1571 1233.0	0.1672 1259.3
3200.0	3185.3	705.11	v_f h_v	– –	– –	0.1226 1151.1	0.1369 1191.4	0.1486 1223.5	0.1589 1251.1
3206.2	3191.5	705.40	v_f h_v	– –	– –	0.1220 1150.2	0.1363 1190.6	0.1480 1222.9	0.1583 1250.5

Pressure (psi)		Saturated Temperature (°F)	v_f h_v	Temperature (°F)				
Absolute	Gage			860	900	1000	1100	1200
2900.0	2885.3	690.26	v_f h_v	0.2108 1335.3	0.2254 1369.7	0.2577 1445.1	0.2864 1512.7	0.3132 1576.5
3000.0	2985.3	695.36	v_f h_v	0.2014 1329.7	0.2159 1365.0	0.2476 1441.8	0.2757 1510.0	0.3018 1574.3
3100.0	3085.3	700.31	v_f h_v	0.1926 1324.1	0.2070 1360.3	0.2382 1438.4	0.2657 1507.4	0.2911 1572.1
3200.0	3185.3	705.11	v_f h_v	0.1843 1318.3	0.1986 1355.5	0.2293 1434.9	0.2563 1504.7	0.2811 1569.9
3206.2	3191.5	705.40	v_f h_v	0.1838 1317.9	0.1981 1355.2	0.2288 1434.7	0.2557 1504.5	0.2806 1569.8

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Pipe Data

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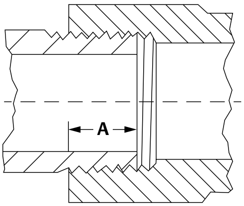
13.1 Pipe Engagement

Length of thread on pipe to make a tight joint:



Nominal Pipe Size (in.)	Dimension A (in.)	Nominal Pipe Size (in.)	Dimension A (in.)
1/8	0.27	1-1/2	0.68
1/4	0.39	2	0.70
3/8	0.41	2-1/2	0.93
1/2	0.53	3	1.02
3/4	0.55	4	1.09
1	0.66	5	1.19
1-1/4	0.68	6	1.21

Dimension A is the sum of L1 (handtight engagement) and L3 (wrench makeup length for internal thread) from ASME B1.20.1-1992.

13.2 Carbon and Alloy Steel — Stainless Steel

Identification, wall thickness, and weights are extracted from ASME B36.10M and B36.19M. The notations STD, XS, and XXS indicate Standard, Extra Strong, and Double Extra Strong pipe, respectively. Transverse internal area values listed in ft² also represent volume in cubic feet per foot of pipe length.

Nom. Pipe Size (in.)	Nom. Diameter (DN)	Outside Diameter (in.)	Identification			Wall Thickness (in.)	Inside Diameter (d) (in.)	Area of Metal (in²)	Transverse Internal Area		Weight Pipe (lb/ft)	Water Weight (lb/ft Pipe)
			Steel		Stainless Steel Schedule				(in²)	(ft²)		
			Iron Pipe Size	Schedule								
1/8	6	0.405	–	–	10S	0.049	0.307	0.0548	0.0740	0.00051	0.19	0.032
			–	30	–	0.057	0.291	0.0623	0.0665	0.00046	0.21	0.029
			STD	40	40S	0.068	0.269	0.0720	0.0568	0.00039	0.24	0.025
			XS	80	80S	0.095	0.215	0.0925	0.0363	0.00025	0.31	0.016
1/4	8	0.540	–	–	10S	0.065	0.410	0.0970	0.1320	0.00092	0.33	0.057
			–	30	–	0.073	0.394	0.1071	0.1219	0.00085	0.36	0.053
			STD	40	40S	0.088	0.364	0.1250	0.1041	0.00072	0.42	0.045
			XS	80	80S	0.119	0.302	0.1574	0.0716	0.00050	0.54	0.031
3/8	10	0.675	–	–	10S	0.065	0.545	0.1246	0.2333	0.00162	0.42	0.101
			–	30	–	0.073	0.529	0.1381	0.2198	0.00153	0.47	0.095
			STD	40	40S	0.091	0.493	0.1670	0.1909	0.00133	0.57	0.083
			XS	80	80S	0.126	0.423	0.2173	0.1405	0.00098	0.74	0.061

13.2 *Carbon and Alloy Steel — Stainless Steel, continued.*

Nom. Pipe Size (in.)	Nom. Diameter (DN)	Outside Diameter (in.)	Identification			Wall Thickness (in.)	Inside Diameter (d) (in.)	Area of Metal (in^2)	Transverse Internal Area		Weight Pipe (lb/ft)	Water Weight (lb/ft Pipe)
			Steel		Stainless Steel Schedule				(in^2)	(ft^2)		
			Iron Pipe Size	Schedule								
1/2	15	0.840	–	–	5S	0.065	0.710	0.1583	0.3959	0.00275	0.54	0.172
			–	–	10S	0.083	0.674	0.1974	0.3568	0.00248	0.67	0.155
			–	30	–	0.095	0.650	0.2223	0.3318	0.00230	0.76	0.144
			STD	40	40S	0.109	0.622	0.2503	0.3039	0.00211	0.85	0.132
			XS	80	80S	0.147	0.546	0.3200	0.2341	0.00163	1.09	0.101
			–	160	–	0.188	0.464	0.3851	0.1691	0.00117	1.31	0.073
			XXS	–	–	0.294	0.252	0.5043	0.0499	0.00035	1.71	0.022
3/4	20	1.050	–	–	5S	0.065	0.920	0.2011	0.6648	0.00462	0.69	0.288
			–	–	10S	0.083	0.884	0.2521	0.6138	0.00426	0.86	0.266
			–	30	–	0.095	0.860	0.2850	0.5809	0.00403	0.97	0.252
			STD	40	40S	0.113	0.824	0.3326	0.5333	0.00370	1.13	0.231
			XS	80	80S	0.154	0.742	0.4335	0.4324	0.00300	1.47	0.187
			–	160	–	0.219	0.612	0.5717	0.2942	0.00204	1.94	0.127
			XXS	–	–	0.308	0.434	0.7180	0.1479	0.00103	2.44	0.064
1	25	1.315	–	–	5S	0.065	1.185	0.2553	1.103	0.00766	0.87	0.478
			–	–	10S	0.109	1.097	0.4130	0.9452	0.00656	1.40	0.410
			–	30	–	0.114	1.087	0.4301	0.9280	0.00644	1.46	0.402
			STD	40	40S	0.133	1.049	0.4939	0.8643	0.00600	1.68	0.375
			XS	80	80S	0.179	0.957	0.6388	0.7193	0.00500	2.17	0.312
			–	160	–	0.250	0.815	0.8365	0.5217	0.00362	2.84	0.226
			XXS	–	–	0.358	0.599	1.0763	0.2818	0.00196	3.66	0.122
1-1/4	32	1.660	–	–	5S	0.065	1.530	0.3257	1.839	0.01277	1.11	0.797
			–	–	10S	0.109	1.442	0.5311	1.633	0.01134	1.81	0.708
			–	30	–	0.117	1.426	0.5672	1.597	0.01109	1.93	0.692
			STD	40	40S	0.140	1.380	0.6685	1.496	0.01039	2.27	0.648
			XS	80	80S	0.191	1.278	0.8815	1.283	0.00891	3.00	0.556
			–	160	–	0.250	1.160	1.1070	1.057	0.00734	3.76	0.458
			XXS	–	–	0.382	0.896	1.5340	0.6305	0.00438	5.21	0.273
1-1/2	40	1.900	–	–	5S	0.065	1.770	0.3747	2.461	0.01709	1.28	1.066
			–	–	10S	0.109	1.682	0.6133	2.222	0.01543	2.09	0.963
			–	30	–	0.125	1.650	0.6970	2.138	0.01485	2.37	0.927
			STD	40	40S	0.145	1.610	0.7995	2.036	0.01414	2.72	0.882
			XS	80	80S	0.200	1.500	1.068	1.767	0.01227	3.63	0.766
			–	160	–	0.281	1.338	1.429	1.406	0.00976	4.86	0.609
			XXS	–	–	0.400	1.100	1.885	0.9503	0.00660	6.41	0.412

13.2 *Carbon and Alloy Steel — Stainless Steel, continued.*

Nom. Pipe Size (in.)	Nom. Dia-meter (DN)	Outside Dia-meter (in.)	Identification			Wall Thick-ness (in.)	Inside Dia-meter (d) (in.)	Area of Metal (in²)	Transverse Internal Area		Weight Pipe (lb/ft)	Water Weight (lb/ft Pipe)
			Steel		Stainless Steel Schedule				(in²)	(ft²)		
			Iron Pipe Size	Schedule								
2	50	2.375	–	–	5S	0.065	2.245	0.4717	3.958	0.02749	1.61	1.715
			–	–	10S	0.109	2.157	0.7760	3.654	0.02538	2.64	1.583
			–	30	–	0.125	2.125	0.8836	3.547	0.02463	3.00	1.537
			STD	40	40S	0.154	2.067	1.075	3.356	0.02330	3.65	1.454
			XS	80	80S	0.218	1.939	1.477	2.953	0.02051	5.02	1.280
			–	160	–	0.344	1.687	2.195	2.235	0.01552	7.46	0.969
			XXS	–	–	0.436	1.503	2.656	1.774	0.01232	9.03	0.769
2-1/2	65	2.875	–	–	5S	0.083	2.709	0.7280	5.764	0.04003	2.48	2.498
			–	–	10S	0.120	2.635	1.039	5.453	0.03787	3.53	2.363
			–	30	–	0.188	2.499	1.587	4.905	0.03406	5.40	2.125
			STD	40	40S	0.203	2.469	1.704	4.788	0.03325	5.79	2.075
			XS	80	80S	0.276	2.323	2.254	4.238	0.02943	7.66	1.837
			–	160	–	0.375	2.125	2.945	3.547	0.02463	10.01	1.537
			XXS	–	–	0.552	1.771	4.028	2.463	0.01711	13.69	1.067
3	80	3.500	–	–	5S	0.083	3.334	0.8910	8.730	0.06063	3.03	3.783
			–	–	10S	0.120	3.260	1.274	8.347	0.05796	4.33	3.617
			30	–	–	0.188	3.124	1.956	7.665	0.05323	6.65	3.322
			STD	40	40S	0.216	3.068	2.228	7.393	0.05134	7.58	3.203
			XS	80	80S	0.300	2.900	3.016	6.605	0.04587	10.25	2.862
			–	160	–	0.438	2.624	4.213	5.408	0.03755	14.32	2.343
			XXS	–	–	0.600	2.300	5.466	4.155	0.02885	18.58	1.800
3-1/2	90	4.000	–	–	5S	0.083	3.834	1.021	11.55	0.08017	3.48	5.003
			–	–	10S	0.120	3.760	1.463	11.10	0.07711	4.97	4.812
			30	–	–	0.188	3.624	2.251	10.31	0.07163	7.65	4.470
			STD	40	40S	0.226	3.548	2.680	9.887	0.06866	9.11	4.284
			XS	80	80S	0.318	3.364	3.678	8.888	0.06172	12.50	3.851
4	100	4.500	–	–	5S	0.083	4.334	1.152	14.75	0.10245	3.92	6.393
			–	–	10S	0.120	4.260	1.651	14.25	0.09898	5.61	6.176
			–	30	–	0.188	4.124	2.547	13.36	0.09276	8.66	5.788
			STD	40	40S	0.237	4.026	3.174	12.73	0.08840	10.79	5.516
			XS	80	80S	0.337	3.826	4.407	11.50	0.07984	14.98	4.982
			–	120	–	0.438	3.624	5.589	10.31	0.07163	19.00	4.470
			–	160	–	0.531	3.438	6.621	9.283	0.06447	22.51	4.023
			XXS	–	–	0.674	3.152	8.101	7.803	0.05419	27.54	3.381

13.2 *Carbon and Alloy Steel — Stainless Steel, continued.*

Nom. Pipe Size (in.)	Nom. Diameter (DN)	Outside Diameter (in.)	Identification			Wall Thickness (in.)	Inside Diameter (d) (in.)	Area of Metal (in^2)	Transverse Internal Area		Weight Pipe (lb/ft)	Water Weight (lb/ft Pipe)
			Steel		Stainless Steel Schedule							
			Iron Pipe Size	Schedule					(in^2)	(ft^2)		
5	125	5.563	–	–	5S	0.109	5.345	1.868	22.44	0.15582	6.36	9.723
			–	–	10S	0.134	5.295	2.285	22.02	0.15292	7.77	9.542
			STD	40	40S	0.258	5.047	4.300	20.01	0.13893	14.62	8.669
			XS	80	80S	0.375	4.813	6.112	18.19	0.12635	20.78	7.884
			–	120	–	0.500	4.563	7.953	16.35	0.11356	27.04	7.086
			–	160	–	0.625	4.313	9.696	14.61	0.10146	32.96	6.331
			XXS	–	–	0.750	4.063	11.34	12.97	0.09004	38.55	5.618
6	150	6.625	–	–	5S	0.109	6.407	2.231	32.24	0.22389	7.60	13.97
			–	–	10S	0.134	6.357	2.733	31.74	0.22041	9.29	13.75
			STD	40	40S	0.28	6.065	5.581	28.89	0.20063	18.97	12.52
			XS	80	80S	0.432	5.761	8.405	26.07	0.18102	28.57	11.30
			–	120	–	0.562	5.501	10.70	23.77	0.16505	36.39	10.30
			–	160	–	0.719	5.187	13.34	21.13	0.14674	45.35	9.157
			XXS	–	–	0.864	4.897	15.64	18.83	0.13079	53.16	8.162
8	200	8.625	–	–	5S	0.109	8.407	2.916	55.51	0.38549	9.93	24.05
			–	–	10S	0.148	8.329	3.941	54.48	0.37837	13.40	23.61
			–	20	–	0.25	8.125	6.578	51.85	0.36006	22.36	22.47
			–	30	–	0.277	8.071	7.265	51.16	0.35529	24.70	22.17
			STD	40	40S	0.322	7.981	8.399	50.03	0.34741	28.55	21.68
			–	60	–	0.406	7.813	10.48	47.94	0.33294	35.64	20.78
			XS	80	80S	0.5	7.625	12.76	45.66	0.31711	43.39	19.79
			–	100	–	0.594	7.437	14.99	43.44	0.30166	50.95	18.82
			–	120	–	0.719	7.187	17.86	40.57	0.28172	60.71	17.58
			–	140	–	0.812	7.001	19.93	38.50	0.26733	67.76	16.68
			XXS	–	–	0.875	6.875	21.30	37.12	0.25779	72.42	16.09
			–	160	–	0.906	6.813	21.97	36.46	0.25317	74.69	15.80

13.2 *Carbon and Alloy Steel — Stainless Steel, continued.*

Nom. Pipe Size (in.)	Nom. Diameter (DN)	Outside Diameter (in.)	Identification			Wall Thickness (in.)	Inside Diameter (d) (in.)	Area of Metal (in²)	Transverse Internal Area		Weight Pipe (lb/ft)	Water Weight (lb/ft Pipe)
			Steel		Stainless Steel Schedule							
			Iron Pipe Size	Schedule					(in²)	(ft²)		
10	250	10.750	–	–	5S	0.134	10.482	4.469	86.29	0.59926	15.19	37.39
			–	–	10S	0.165	10.420	5.487	85.28	0.59219	18.65	36.95
			–	20	–	0.250	10.250	8.247	82.52	0.57303	28.04	35.76
			–	30	–	0.307	10.136	10.07	80.69	0.56035	34.24	34.97
			STD	40	40S	0.365	10.020	11.91	78.85	0.54760	40.48	34.17
			XS	60	80S	0.500	9.750	16.10	74.66	0.51849	54.74	32.35
			–	80	–	0.594	9.562	18.95	71.81	0.49868	64.43	31.12
			–	100	–	0.719	9.312	22.66	68.10	0.47295	77.03	29.51
			–	120	–	0.844	9.062	26.27	64.50	0.44790	89.29	27.95
			XXS	140	–	1.000	8.750	30.63	60.13	0.41758	104.13	26.06
			–	160	–	1.125	8.500	34.02	56.75	0.39406	115.64	24.59
12	300	12.750	–	–	5S	0.156	12.438	6.172	121.5	0.84378	20.98	52.65
			–	–	10S	0.180	12.390	7.108	120.6	0.83728	24.17	52.25
			–	20	–	0.250	12.250	9.818	117.9	0.81847	33.38	51.07
			–	30	–	0.330	12.090	12.88	114.8	0.79723	43.77	49.75
			STD	–	40S	0.375	12.000	14.58	113.1	0.78540	49.56	49.01
			–	40	–	0.406	11.938	15.74	111.9	0.77731	53.52	48.50
			XS	–	80S	0.500	11.750	19.24	108.4	0.75302	65.42	46.99
			–	60	–	0.562	11.626	21.52	106.2	0.73721	73.15	46.00
			–	80	–	0.688	11.374	26.07	101.6	0.70559	88.63	44.03
			–	100	–	0.844	11.062	31.57	96.11	0.66741	107.32	41.65
			XXS	120	–	1.000	10.750	36.91	90.76	0.63030	125.49	39.33
			–	140	–	1.125	10.500	41.09	86.59	0.60132	139.67	37.52
			–	160	–	1.312	10.126	47.14	80.53	0.55925	160.27	34.90

13.2 *Carbon and Alloy Steel — Stainless Steel, continued.*

Nom. Pipe Size (in.)	Nom. Dia-meter (DN)	Outside Dia-meter (in.)	Identification			Wall Thick-ness (in.)	Inside Dia-meter (d) (in.)	Area of Metal (in²)	Transverse Internal Area		Weight Pipe (lb/ft)	Water Weight (lb/ft Pipe)
			Steel		Stainless Steel Schedule							
			Iron Pipe Size	Schedule					(in²)	(ft²)		
14	350	14.000	–	–	5S	0.156	13.688	6.785	147.2	1.02190	23.07	63.77
			–	–	10S	0.188	13.624	8.158	145.8	1.01237	27.73	63.17
			–	10	–	0.250	13.500	10.80	143.1	0.99402	36.71	62.03
			–	20	–	0.312	13.376	13.42	140.5	0.97585	45.61	60.89
			STD	30	–	0.375	13.250	16.05	137.9	0.95755	54.57	59.75
			–	40	–	0.438	13.124	18.66	135.3	0.93942	63.44	58.62
			XS	–	–	0.500	13.000	21.21	132.7	0.92175	72.09	57.52
			–	60	–	0.594	12.812	25.02	128.9	0.89529	85.05	55.87
			–	80	–	0.750	12.500	31.22	122.7	0.85221	106.13	53.18
			–	100	–	0.938	12.124	38.49	115.4	0.80172	130.85	50.03
			–	120	–	1.094	11.812	44.36	109.6	0.76098	150.79	47.49
			–	140	–	1.250	11.500	50.07	103.9	0.72131	170.21	45.01
			–	160	–	1.406	11.188	55.63	98.31	0.68271	189.11	42.60
16	400	1600	–	–	5S	0.165	15.670	8.208	192.9	1.33926	27.90	83.57
			–	–	10S	0.188	15.624	9.339	191.7	1.33141	31.75	83.08
			–	10	–	0.250	15.500	12.37	188.7	1.31036	42.05	81.77
			–	20	–	0.312	15.376	15.38	185.7	1.28948	52.27	80.46
			STD	30	–	0.375	15.250	18.41	182.7	1.26843	62.58	79.15
			XS	40	–	0.500	15.000	24.35	176.7	1.22719	82.77	76.58
			–	60	–	0.656	14.688	31.62	169.4	1.17667	107.50	73.42
			–	80	–	0.844	14.312	40.19	160.9	1.11720	136.61	69.71
			–	100	–	1.031	13.938	48.48	152.6	1.05957	164.82	66.12
			–	120	–	1.219	13.562	56.61	144.5	1.00317	192.43	62.60
			–	140	–	1.438	13.124	65.79	135.3	0.93942	223.64	58.62
			–	160	–	1.594	12.812	72.14	128.9	0.89529	245.25	55.87

13.2 *Carbon and Alloy Steel — Stainless Steel, continued.*

Nom. Pipe Size (in.)	Nom. Dia-meter (DN)	Outside Dia-meter (in.)	Identification			Wall Thick-ness (in.)	Inside Dia-meter (d) (in.)	Area of Metal (in²)	Transverse Internal Area		Weight Pipe (lb/ft)	Water Weight (lb/ft Pipe)
			Steel		Stainless Steel Schedule				(in²)	(ft²)		
			Iron Pipe Size	Schedule								
18	450	18.000	–	–	5S	0.165	17.670	9.245	245.2	1.70295	31.43	106.3
			–	–	10S	0.188	17.624	10.52	243.9	1.69409	35.76	105.7
			–	10	–	0.250	17.500	13.94	240.5	1.67034	47.39	104.2
			–	20	–	0.312	17.376	17.34	237.1	1.64675	58.94	102.8
			STD	–	–	0.375	17.250	20.76	233.7	1.62296	70.59	101.3
			–	30	–	0.438	17.124	24.17	230.3	1.59933	82.15	99.80
			XS	–40	–	0.500	17.000	27.49	227.0	1.57625	93.45	98.36
			–		–	0.562	16.876	30.79	223.7	1.55334	104.67	96.93
			–	60	–	0.750	16.500	40.64	213.8	1.48490	138.17	92.66
			–	80	–	0.938	16.124	50.28	204.2	1.41799	170.92	88.48
			–	100	–	1.156	15.688	61.17	193.3	1.34234	207.96	83.76
			–	120	–	1.375	15.250	71.82	182.7	1.26843	244.14	79.15
			–	140	–	1.562	14.876	80.66	173.8	1.20698	274.22	75.32
			–	160	–	1.781	14.438	90.75	163.7	1.13695	308.50	70.95
20	500	20.000	–	–	5S	0.188	19.624	11.70	302.5	2.10041	39.78	131.1
			–	–	10S	0.218	19.564	13.55	300.6	2.08758	46.06	130.3
			–	10	–	0.250	19.500	15.51	298.6	2.07395	52.73	129.4
			STD	20	–	0.375	19.250	23.12	291.0	2.02111	78.60	126.1
			XS	30	–	0.500	19.000	30.63	283.5	1.96895	104.13	122.9
			–	40	–	0.594	18.812	36.21	277.9	1.93018	123.11	120.4
			–	60	–	0.812	18.376	48.95	265.2	1.84175	166.40	114.9
			–	80	–	1.031	17.938	61.44	252.7	1.75500	208.87	109.5
			–	100	–	1.281	17.438	75.33	238.8	1.65852	256.10	103.5
			–	120	–	1.500	17.000	87.18	227.0	1.57625	296.37	98.36
			–	140	–	1.750	16.500	100.3	213.8	1.48490	341.09	92.66
			–	160	–	1.969	16.062	111.5	202.6	1.40711	379.17	87.80

13.2 *Carbon and Alloy Steel — Stainless Steel, continued.*

Nom. Pipe Size (in.)	Nom. Diameter (DN)	Outside Diameter (in.)	Identification: Steel: Iron Pipe Size	Identification: Steel: Schedule	Identification: Stainless Steel Schedule	Wall Thickness (in.)	Inside Diameter (d) (in.)	Area of Metal (in^2)	Transverse Internal Area (in^2)	Transverse Internal Area (ft^2)	Weight Pipe (lb/ft)	Water Weight (lb/ft Pipe)
22	550	22.000	–	–	5S	0.188	21.624	12.88	367.3	2.55035	43.80	159.1
			–	–	10S	0.218	21.564	14.92	365.2	2.53622	50.71	158.3
			–	10	–	0.250	21.500	17.08	363.1	2.52119	58.07	157.3
			STD	20	–	0.375	21.250	25.48	354.7	2.46290	86.61	153.7
			XS	30	–	0.500	21.000	33.77	346.4	2.40529	114.81	150.1
			–	60	–	0.875	20.250	58.07	322.1	2.23655	197.41	139.6
			–	80	–	1.125	19.750	73.78	306.4	2.12747	250.81	132.8
			–	100	–	1.375	19.250	89.09	291.0	2.02111	302.88	126.1
			–	120	–	1.625	18.750	104.0	276.1	1.91748	353.61	119.7
			–	140	–	1.875	18.250	118.5	261.6	1.81658	403.00	113.4
			–	160	–	2.125	17.750	132.7	247.5	1.71840	451.06	107.2
24	600	24.000	–	–	5S	0.218	23.564	16.29	436.1	3.02849	55.37	189.0
			10	–	10S	0.250	23.500	18.65	433.7	3.01206	63.41	188.0
			STD	20	–	0.375	23.250	27.83	424.6	2.94832	94.62	184.0
			XS	–	–	0.500	23.000	36.91	415.5	2.88525	125.49	180.0
			–	30	–	0.562	22.876	41.38	411.0	2.85423	140.68	178.1
			–	40	–	0.688	22.624	50.39	402.0	2.79169	171.29	174.2
			–	60	–	0.969	22.062	70.11	382.3	2.65472	238.35	165.7
			–	80	–	1.219	21.562	87.24	365.1	2.53575	296.58	158.2
			–	100	–	1.531	20.938	108.1	344.3	2.39111	367.39	149.2
			–	120	–	1.812	20.376	126.3	326.1	2.26447	429.39	141.3
			–	140	–	2.062	19.876	142.1	310.3	2.15470	483.12	134.5
			–	160	–	2.344	19.312	159.5	292.9	2.03415	542.13	126.9
26	650	26.000	–	10	–	0.312	25.376	25.18	505.8	3.51216	85.60	219.2
			STD	–	–	0.375	25.250	30.19	500.7	3.47737	102.63	217.0
			XS	20	–	0.500	25.000	40.06	490.9	3.40885	136.17	212.7
28	700	28.000	–	10	–	0.312	27.376	27.14	588.6	4.08760	92.26	255.1
			STD	–	–	0.375	27.250	32.55	583.2	4.05006	110.64	252.7
			XS	20	–	0.500	27.000	43.20	572.6	3.97609	146.85	248.1
			–	30	–	0.625	26.750	53.75	562.0	3.90280	182.73	243.5
30	750	30.000	–	–	5S	0.250	29.500	23.37	683.5	4.74649	79.43	296.2
			10	–	10S	0.312	29.376	29.10	677.8	4.70667	98.93	293.7
			STD	–	–	0.375	29.250	34.90	672.0	4.66638	118.65	291.2
			XS	20	–	0.500	29.000	46.34	660.5	4.58695	157.53	286.2
			–	30	–	0.625	28.750	57.68	649.2	4.50821	196.08	281.3

13.2 *Carbon and Alloy Steel — Stainless Steel, continued.*

Nom. Pipe Size (in.)	Nom. Dia-meter (DN)	Outside Dia-meter (in.)	Identification			Wall Thick-ness (in.)	Inside Dia-meter (d) (in.)	Area of Metal (in²)	Transverse Internal Area		Weight Pipe (lb/ft)	Water Weight (lb/ft Pipe)
			Steel		Stainless Steel Schedule				(in²)	(ft²)		
			Iron Pipe Size	Schedule								
32	800	32.000	–	10	–	0.312	31.376	31.06	773.2	5.36937	105.59	335.0
			STD	–	–	0.375	31.250	37.26	767.0	5.32633	126.66	332.4
			XS	20	–	0.500	31.000	49.48	754.8	5.24145	168.21	327.1
			–	30	–	0.625	30.750	61.60	742.6	5.15726	209.43	321.8
			–	40	–	0.688	30.624	67.68	736.6	5.11508	230.08	319.2
34	850	34.000	–	10	–	0.312	33.376	33.02	874.9	6.07571	112.25	379.1
			STD	–	–	0.375	33.250	39.61	868.3	6.02992	134.67	376.3
			XS	20	–	0.500	33.000	52.62	855.3	5.93959	178.89	370.6
			–	30	–	0.625	32.750	65.53	842.4	5.84993	222.78	365.0
			–	40	–	0.688	32.624	72.00	835.9	5.80501	244.77	362.2
36	900	36.000	–	10	–	0.312	35.376	34.98	982.9	6.82568	118.92	425.9
			STD	–	–	0.375	35.250	41.97	975.9	6.77714	142.68	422.9
			XS	20	–	0.500	35.000	55.76	962.1	6.68135	189.57	416.9
			–	30	–	0.625	34.750	69.46	948.4	6.58625	236.13	411.0
			–	40	–	0.750	34.500	83.06	934.8	6.49182	282.35	405.1

13.3 American Pipe Flange Dimensions

13.3.1 Diameter of Bolt Circles

In inches per ASME B16.1, B16.5, and B16.24.

Nominal Pipe Size	Class[1] 125 (Cast Iron)[2] or Class 150 (Steel)	Class[3] 250 (Cast Iron)[2] or Class 300 (Steel)	Class 600	Class 900	Class 1500	Class 2500
1	3.12	3.50	3.50	4.00	4.00	4.25
1-1/4	3.50	3.88	3.88	4.38	4.38	5.12
1-1/2	3.88	4.50	4.50	4.88	4.88	5.75
2	4.75	5.00	5.00	6.50	6.50	6.75
2-1/2	5.50	5.88	5.88	7.50	7.50	7.75
3	6.00	6.62	6.62	7.50	8.00	9.00
4	7.50	7.88	8.50	9.25	9.50	10.75
5	8.50	9.25	10.50	11.00	11.50	12.75
6	9.50	10.62	11.50	12.50	12.50	14.50
8	11.75	13.00	13.75	15.50	15.50	17.25
10	14.25	15.25	17.00	18.50	19.00	21.75
12	17.00	17.75	19.25	21.00	22.50	24.38
14	18.75	20.25	20.75	22.00	25.00	–
16	21.25	22.50	23.75	24.25	27.75	–
18	22.75	24.75	25.75	27.00	30.50	–
20	25.00	27.00	28.50	29.50	32.75	–
24	29.50	32.00	33.00	35.50	39.00	–
30	36.00	39.25	–	–	–	–
36	42.75	46.00	–	–	–	–
42	49.50	52.75	–	–	–	–
48	56.00	60.75	–	–	–	–

1. Nominal pipe sizes 1 through 12 also apply to Class 150 cast copper alloy flanges.
2. These diameters apply to steel flanges for nominal pipe sizes 1 through 24.
3. Nominal pipe sizes 1 through 8 also apply to Class 300 cast copper alloy flanges.

13.3.2 Number of Stud Bolts and Diameter

In inches per ASME B16.1, B16.5, and B16.24.

Nominal Pipe Size	Class[1] 125 (Cast Iron)[2] or Class 150 (Steel)		Class[3] 250 (Cast Iron)[2] or Class 300 (Steel)		Class 600		Class 900		Class 1500		Class 2500	
	No.	D	No.	D	No.	D	No.	D	No.	D	No.	D
1	4	0.50	4	0.62	4	0.62	4	0.88	4	0.88	4	0.88
1-1/4	4	0.50	4	0.62	4	0.62	4	0.88	4	0.88	4	1.00
1-1/2	4	0.50	4	0.75	4	0.75	4	1.00	4	1.00	4	1.12
2	4	0.62	8	0.62	8	0.62	8	0.88	8	0.88	8	1.00
2-1/2	4	0.62	8	0.75	8	0.75	8	1.00	8	1.00	8	1.12
3	4	0.62	8	0.75	8	0.75	8	0.88	8	1.12	8	1.25
4	8	0.62	8	0.75	8	0.88	8	1.12	8	1.25	8	1.50
5	8	0.75	8	0.75	8	1.00	8	1.25	8	1.50	8	1.75
6	8	0.75	12	0.75	12	1.00	12	1.12	12	1.38	8	2.00
8	8	0.75	12	0.88	12	1.12	12	1.38	12	1.62	12	2.00
10	12	0.88	16	1.00	16	1.25	16	1.38	12	1.88	12	2.50
12	12	0.88	16	1.12	20	1.25	20	1.38	16	2.00	12	2.75
14	12	1.00	20	1.12	20	1.38	20	1.50	16	2.25	–	–
16	16	1.00	20	1.25	20	1.50	20	1.62	16	2.50	–	–
18	16	1.12	24	1.25	20	1.62	20	1.88	16	2.75	–	–
20	20	1.12	24	1.25	24	1.62	20	2.00	16	3.00	–	–
24	20	1.25	24	1.50	24	1.88	20	2.50	16	3.50	–	–
30	28	1.25	28	1.75	–	–	–	–	–	–	–	–
36	32	1.50	32	2.00	–	–	–	–	–	–	–	–
42	36	1.50	36	2.00	–	–	–	–	–	–	–	–
48	44	1.50	40	2.00	–	–	–	–	–	–	–	–

1. Nominal pipe sizes 1 through 12 also apply to Class 150 cast copper alloy flanges.
2. These diameters apply to steel flanges for nominal pipe sizes 1 through 24.
3. Nominal pipe sizes 1 through 8 also apply to Class 300 cast copper alloy flanges.

13.3.3 Flange Diameter

In inches per ASME B16.1, B16.5, and B16.24.

Nominal Pipe Size	Class[1] 125 (Cast Iron)[2] or Class 150 (Steel)	Class[3] 250 (Cast Iron)[2] or Class 300 (Steel)	Class 600	Class 900	Class 1500	Class 2500
1	4.25	4.88	4.88	5.88	5.88	6.25
1–1/4	4.62	5.25	5.25	6.25	6.25	7.25
1–1/2	5.00	6.12	6.12	7.00	7.00	8.00
2	6.00	6.50	6.50	8.50	8.50	9.25
2–1/2	7.00	7.50	7.50	9.62	9.62	10.50
3	7.50	8.25	8.25	9.50	10.50	12.00
4	9.00	10.00	10.75	11.50	12.25	14.00
5	10.00	11.00	13.00	13.75	14.75	16.50
6	11.00	12.50	14.00	15.00	15.50	19.00
8	13.50	15.00	16.50	18.50	19.00	21.75
10	16.00	17.50	20.00	21.50	23.00	26.50
12	19.00	20.50	22.00	24.00	26.50	30.00
14	21.00	23.00	23.75	25.25	29.50	–
16	23.50	25.50	27.00	27.75	32.50	–
18	25.00	28.00	29.25	31.00	36.00	–
20	27.50	30.50	32.00	33.75	38.75	–
24	32.00	36.00	37.00	41.00	46.00	–
30	38.75	43.00	–	–	–	–
36	46.00	50.00	–	–	–	–
42	53.00	57.00	–	–	–	–
48	59.50	65.00	–	–	–	–

1. Nominal pipe sizes 1 through 12 also apply to Class 150 cast copper alloy flanges.
2. Nominal pipe sizes 1 through 8 also apply to Class 300 cast copper alloy flanges.

13.3.4 Flange Thickness for Flange Fittings

In inches per ASME B16.1, B16.5, and B16.24. CI = cast iron, FF = flat face, and STL = steel

Nominal Pipe Size	Class 150 (CI) FF and STL	Class 150 STL	Class 150	Class 250 (CI) and Class 300 STL[1]	Class 300 STL	CL 300
	RF[2]	RTJ	Cast Copper Alloy	RF	RTJ	Cast Copper Alloy
1	0.50	0.75	0.38	0.62	0.87	0.59
1-1/4	0.56	0.81	0.41	0.69	0.94	0.62
1-1/2	0.62	0.87	0.44	0.75	1.00	0.69
2	0.69	0.94	0.50	0.81	1.12	0.75
2-1/2	0.81	1.06	0.56	0.94	1.25	0.81
3	0.88	1.13	0.62	1.06	1.37	0.91
4	0.88	1.13	0.69	1.19	1.50	1.06
5	0.88	1.13	0.75	1.31	1.62	1.12

Nominal Pipe Size	Class 600		Class 900		Class 1500		Class 2500	
	RF	RTJ	RF	RTJ	RF	RTJ	RF	RTJ
1	0.69	0.94	1.12	1.37	1.12	1.37	1.38	1.63
1-1/4	0.81	1.06	1.12	1.37	1.12	1.37	1.50	1.81
1-1/2	0.88	1.13	1.25	1.50	1.25	1.50	1.75	2.06
2	1.00	1.31	1.50	1.81	1.50	1.81	2.00	2.31
2-1/2	1.12	1.43	1.62	1.93	1.62	1.93	2.25	2.62
3	1.25	1.56	1.50	1.81	1.88	2.43	2.62	3.00
4	1.50	1.81	1.75	2.06	2.12	2.43	3.00	3.44
5	1.75	2.06	2.00	2.31	2.88	3.19	3.62	4.12

13.3.4 Flange Thickness for Flange Fittings, continued.

Nominal Pipe Size	Class 150 (CI) FF and STL	Class 150 STL	Class 150	Class 250 (CI) and Class 300 STL[1]	Class 300 STL	CL 300
	RF[2]	RTJ	Cast Copper Alloy	RF	RTJ	Cast Copper Alloy
6	0.94	1.19	0.81	1.38	1.69	1.19
8	1.06	1.31	0.94	1.56	1.87	1.38
10	1.12	1.37	1.00	1.81	2.12	–
12	1.19	1.44	1.06	1.94	2.25	–
14	1.31	1.56	–	2.06	2.37	–
16	1.38	1.63	–	2.19	2.50	–
18	1.50	1.75	–	2.31	2.62	–
20	1.62	1.87	–	2.44	2.82	–
24	1.81	2.06	–	2.69	3.13	–

Nominal Pipe Size	Class 600		Class 900		Class 1500		Class 2500	
	RF	RTJ	RF	RTJ	RF	RTJ	RF	RTJ
6	1.88	2.19	2.19	2.50	3.25	3.62	4.25	4.75
8	2.19	2.50	2.50	2.81	3.62	4.06	5.00	5.56
10	2.50	2.81	2.75	3.06	4.25	4.69	6.50	7.19
12	2.62	2.93	3.12	3.43	4.88	5.44	7.25	7.94
14	2.75	3.06	3.38	3.82	5.25	5.88	–	–
16	3.00	3.31	3.50	3.94	5.75	6.44	–	–
18	3.25	3.56	4.00	4.50	6.38	7.07	–	–
20	3.50	3.88	4.25	4.75	7.00	7.69	–	–
24	4.00	4.44	5.50	6.12	8.00	8.81	–	–

1. These dimensions apply to steel flanges for nominal pipe sizes 1 through 24.
2. The flange dimensions listed are for regularly furnished 0.06-in. raised face.

13.4 Cast Steel Flange Standards

13.4.1 Cast Steel Flange Standard for PN 10

DN	Flange			Bolting		
	Outside Diameter	Thickness	Bolt Circle Diameter	Number of Bolts	Threads	Bolt Hole Diameter
10	90	16	60	4	M12	14
15	95	16	65	4	M12	14
20	105	18	75	4	M12	14
25	115	18	85	4	M12	14
32	140	18	100	4	M16	18
40	150	18	110	4	M16	18
50	165	18	125	4	M16	18
65	185	18	145	8	M16	18
80	200	20	160	8	M16	18
100	220	20	180	8	M16	18
125	250	22	210	8	M16	18
150	285	22	240	8	M20	22
200	340	24	295	8	M20	22
250	395	26	350	12	M20	22
300	445	26	400	12	M20	22
350	505	26	460	16	M20	22
400	565	26	515	16	M24	26
450	615	28	565	20	M24	26
500	670	28	620	20	M24	26
600	780	30	725	20	M27	30
700	895	35	840	24	M27	30
800	1015	38	950	24	M30	33
900	1115	38	1050	28	M30	33
1000	1230	44	1160	28	M33	36
1200	1455	55	1380	32	M36	39
1400	1675	65	1590	36	M39	42
1600	1915	75	1820	40	M45	48
1800	2115	85	2020	44	M45	48
2000	2325	90	2230	48	M45	48
2200	2550	100	2440	52	M52	56
2400	2760	110	2650	56	M52	56
2600	2960	110	2850	60	M52	56
2800	3180	124	3070	64	M52	56
3000	3405	132	3290	68	M56	62

All dimensions in mm.

13.4.2 Cast Steel Flange Standard for PN 16

DN	Flange			Bolting		
	Outside Diameter	Thickness	Bolt Circle Diameter	Number of Bolts	Threads	Bolt Hole Diameter
10	90	16	60	4	M12	14
15	95	16	65	4	M12	14
20	105	18	75	4	M12	14
25	115	18	85	4	M12	14
32	140	18	100	4	M16	18
40	150	18	110	4	M16	18
50	165	18	125	4	M16	18
65	185	18	145	4	M16	18
80	200	20	160	8	M16	18
100	220	20	180	8	M16	18
125	250	22	210	8	M16	18
150	285	22	240	8	M20	22
200	340	24	295	12	M20	22
250	405	26	355	12	M24	26
300	460	28	410	12	M24	26
350	520	30	470	16	M24	26
400	580	32	525	16	M27	30
500	715	36	650	20	M30	33
600	840	40	770	20	M33	36
700	910	40	840	24	M33	36
800	1025	41	950	24	M36	39
900	1125	48	1050	28	M36	39
1000	1255	59	1170	28	M39	42
1200	1485	78	1390	32	M45	48
1400	1685	84	1590	36	M45	48
1600	1930	102	1820	40	M52	56
1800	2130	110	2020	44	M52	56
2000	2345	124	2230	48	M56	62

All dimensions in mm.

13.4.3 Cast Steel Flange Standard for PN 25

DN	Flange			Bolting		
	Outside Diameter	Thickness	Bolt Circle Diameter	Number of Bolts	Threads	Bolt Hole Diameter
10	90	16	60	4	M12	14
15	95	16	65	4	M12	14
20	105	18	75	4	M12	14
25	115	18	85	4	M12	14
32	140	18	100	4	M16	18
40	150	18	110	4	M16	18
50	165	20	125	4	M16	18
65	185	22	145	8	M16	18
80	200	24	160	8	M16	18
100	235	24	190	8	M20	22
125	270	26	220	8	M24	26
150	300	28	250	8	M24	26
200	360	30	310	12	M24	26
250	425	32	370	12	M27	30
300	485	34	430	16	M27	30
350	555	38	490	16	M30	33
400	620	40	550	16	M33	36
500	730	48	660	20	M33	36
600	845	48	770	20	M36	39
700	960	50	875	24	M39	42
800	1085	53	990	24	M45	48
900	1185	57	1090	28	M45	48
1000	1320	63	1210	28	M52	56

All dimensions in mm.

13.4.4 Cast Steel Flange Standard for PN 40

DN	Flange			Bolting		
	Outside Diameter	Thickness	Bolt Circle Diameter	Number of Bolts	Threads	Bolt Hole Diameter
10	90	16	60	4	M12	14
15	95	16	65	4	M12	14
20	105	18	75	4	M12	14
25	115	18	85	4	M12	14
32	140	18	100	4	M16	18
40	150	18	110	4	M16	18
50	165	20	125	4	M16	18
65	185	22	145	8	M16	18
80	200	24	160	8	M16	18
100	235	24	190	8	M20	22
125	270	26	220	8	M24	26
150	300	28	250	8	M24	26
200	375	34	320	12	M27	30
250	450	38	385	12	M30	33
300	515	42	450	16	M30	33
350	580	46	510	16	M33	36
400	660	50	585	16	M36	39
450	685	57	610	20	M36	39
500	755	57	670	20	M39	42
600	890	72	795	20	M45	48

All dimensions in mm.

13.4.5 Cast Steel Flange Standard for PN 63

DN	Flange			Bolting		
	Outside Diameter	Thickness	Bolt Circle Diameter	Number of Bolts	Threads	Bolt Hole Diameter
10	100	20	70	4	M12	14
15	105	20	75	4	M12	14
25	140	24	100	4	M16	18
32	155	24	110	4	M20	22
40	170	28	125	4	M20	22
50	180	26	135	4	M20	22
65	205	26	160	8	M20	22
80	215	28	170	8	M20	22
100	250	30	200	8	M24	26
125	295	34	240	8	M27	30
150	345	36	280	8	M30	33
200	415	42	345	12	M33	36
250	470	46	400	12	M33	36
300	530	52	460	16	M33	36
350	600	56	525	16	M36	39
400	670	60	585	16	M39	42

All dimensions in mm.

13.4.6 Cast Steel Flange Standard for PN 100

DN	Flange			Bolting		
	Outside Diameter	Thickness	Bolt Circle Diameter	Number of Bolts	Threads	Bolt Hole Diameter
10	100	20	70	4	M12	14
15	105	20	75	4	M12	14
25	140	24	100	4	M16	18
32	155	24	110	4	M20	22
40	170	28	125	4	M20	22
50	195	30	145	4	M24	26
65	220	34	170	8	M24	26
80	230	36	180	8	M24	26
100	265	40	210	8	M27	30
125	315	40	250	8	M30	33
150	355	44	290	12	M30	33
200	430	52	360	12	M33	36
250	505	60	430	12	M36	39
300	585	68	500	16	M39	42
350	655	74	560	16	M45	48

All dimensions in mm.

13.4.7 Cast Steel Flange Standard for PN 160

DN	Flange			Bolting		
	Outside Diameter	Thickness	Bolt Circle Diameter	Number of Bolts	Threads	Bolt Hole Diameter
10	100	20	70	4	M12	14
15	105	20	75	4	M12	14
25	140	24	100	4	M16	18
40	170	28	125	4	M20	22
50	195	30	145	4	M24	26
65	220	34	170	8	M24	26
80	230	36	180	8	M24	26
100	265	40	210	8	M27	30
125	315	44	250	8	M30	33
150	355	50	290	12	M30	33
200	430	60	360	12	M33	36
250	515	68	430	12	M39	42
300	585	78	500	16	M39	42

All dimensions in mm.

13.4.8 Cast Steel Flange Standard for PN 250

DN	Flange			Bolting		
	Outside Diameter	Thickness	Bolt Circle Diameter	Number of Bolts	Threads	Bolt Hole Diameter
10	125	24	85	4	M16	18
15	130	26	90	4	M16	18
25	150	28	105	4	M20	22
40	185	34	135	4	M24	26
50	200	38	150	8	M24	26
65	230	42	180	8	M24	26
80	255	46	200	8	M27	30
100	300	54	235	8	M30	33
125	340	60	275	12	M30	33
150	390	68	320	12	M33	36
200	485	82	400	12	M39	42
250	585	100	490	16	M45	48
300	690	120	590	16	M48	52

All dimensions in mm.

13.4.9 Cast Steel Flange Standard for PN 320

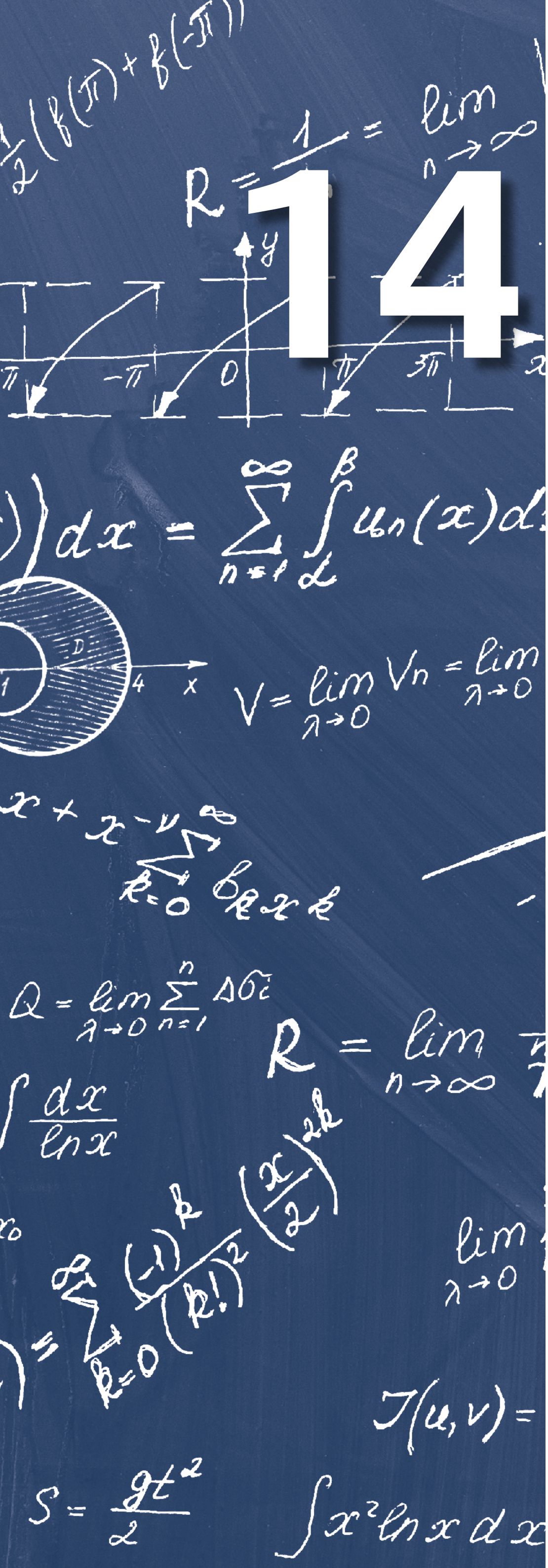
DN	Flange			Bolting		
	Outside Diameter	Thickness	Bolt Circle Diameter	Number of Bolts	Threads	Bolt Hole Diameter
10	125	24	85	4	M16	18
15	130	26	90	4	M16	18
25	160	34	115	4	M20	22
40	195	38	145	4	M24	26
50	210	42	160	8	M24	26
65	255	51	200	8	M27	30
80	275	55	220	8	M27	30
100	335	65	265	8	M33	36
125	380	75	310	12	M33	36
150	425	84	350	12	M36	39
200	525	103	440	16	M39	42
250	640	125	540	16	M48	52

All dimensions in mm.

13.4.10 Cast Steel Flange Standard for PN 400

DN	Flange			Bolting		
	Outside Diameter	Thickness	Bolt Circle Diameter	Number of Bolts	Threads	Bolt Hole Diameter
10	125	28	85	4	M16	18
15	145	30	100	4	M20	22
25	180	38	130	4	M24	26
40	220	48	165	4	M27	30
50	235	52	180	8	M27	30
65	290	64	225	8	M30	33
80	305	68	240	8	M30	33
100	370	80	295	8	M36	39
125	415	92	340	12	M36	39
150	475	105	390	12	M39	42
200	585	130	490	16	M45	48

All dimensions in mm.



14

Conversions and Equivalents

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14.1 Length Equivalents

Note: Use multiplier at convergence of row and column	Meters	Inches	Feet	Millimeters	Miles	Kilometers
Meters	1	39.37	3.2808	1000	0.0006214	0.001
Inches	0.0254	1	0.0833	25.4	0.00001578	0.0000254
Feet	0.3048	12	1	304.8	0.0001894	0.0003048
Millimeters	0.001	0.03937	0.0032808	1	6.2137e-7	0.000001
Miles	1609.35	63,360	5,280	1.6093e6	1	1.60935
Kilometers	1,000	39,370	3280.83	1,000,000	0.62137	1

1 meter = 100 centimeters = 1000 millimeters = 0.001 kilometers = 1,000,000 micrometers.
To convert metric units, adjust the decimal point: 1 millimeter = 1000 microns = 0.03937 inches = 39.37 millimeters.

14.2 Whole Inch to Millimeter Equivalents

Inch	0	1	2	3	4	5	6	7	8	9
	Millimeters									
0	0.0	25.4	50.8	76.2	101.6	127.0	152.4	177.8	203.2	228.6
10	254.0	279.4	304.8	330.2	355.6	381.0	406.4	431.8	457.2	482.6
20	508.0	533.4	558.8	584.2	609.6	635.0	660.4	685.8	711.2	736.6
30	762.0	787.4	812.8	838.2	863.6	889.0	914.4	939.8	965.2	990.6
40	1016.0	1041.4	1066.8	1092.2	1117.6	1143.0	1168.4	1193.8	1219.2	1244.6
50	1270.0	1295.4	1320.8	1346.2	1371.6	1397.0	1422.4	1447.8	1473.2	1498.6
60	1524.0	1549.4	1574.8	1600.2	1625.6	1651.0	1676.4	1701.8	1727.2	1752.6
70	1778.0	1803.4	1828.8	1854.2	1879.6	1905.0	1930.4	1955.8	1981.2	2006.6
80	2032.0	2057.4	2082.8	2108.2	2133.6	2159.0	2184.4	2209.8	2235.2	2260.6
90	2286.0	2311.4	2336.8	2362.2	2387.6	2413.0	2438.4	2463.8	2489.2	2514.6
100	2540.0	2565.4	2590.8	2616.2	2641.6	2667.0	2692.4	2717.8	2743.2	2768.6

Note: All values in this table are exact, based on the relation 1 in. = 25.4 mm. By manipulation of the decimal point any decimal value or multiple of an inch may be converted to its exact equivalent in millimeters.

14.3 Fractional Inch to Millimeter Equivalents

Inch	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16
	Millimeters							
0	0.0	1.6	3.2	4.8	6.4	7.9	9.5	11.1
1	25.4	27.0	28.6	30.2	31.8	33.3	34.9	36.5
2	50.8	52.4	54.0	55.6	57.2	58.7	60.3	61.9
3	76.2	77.8	79.4	81.0	82.6	84.1	85.7	87.3
4	101.6	103.2	104.8	106.4	108.0	109.5	111.1	112.7
5	127.0	128.6	130.2	131.8	133.4	134.9	136.5	138.1
6	152.4	154.0	155.6	157.2	158.8	160.3	161.9	163.5
7	177.8	179.4	181.0	182.6	184.2	185.7	187.3	188.9
8	203.2	204.8	206.4	208.0	209.6	211.1	212.7	214.3
9	228.6	230.2	231.8	233.4	235.0	236.5	238.1	239.7
10	254.0	255.6	257.2	258.8	260.4	261.9	263.5	265.1

1 inch = 25.4 millimeters

Inch	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16
	Millimeters							
0	12.7	14.3	15.9	17.5	19.1	20.6	22.2	23.8
1	38.1	39.7	41.3	42.9	44.5	46.0	47.6	49.2
2	63.5	65.1	66.7	68.3	69.9	71.4	73.0	74.6
3	88.9	90.5	92.1	93.7	95.3	96.8	98.4	100.0
4	114.3	115.9	117.5	119.1	120.7	122.2	123.8	125.4
5	139.7	141.3	142.9	144.5	146.1	147.6	149.2	150.8
6	165.1	166.7	168.3	169.9	171.5	173.0	174.6	176.2
7	190.5	192.1	193.7	195.3	196.9	198.4	200.0	201.6
8	215.9	217.5	219.1	220.7	222.3	223.8	225.4	227.0
9	241.3	242.9	244.5	246.1	247.7	249.2	250.8	252.4
10	266.7	268.3	269.9	271.5	273.1	274.6	276.2	277.8

1 inch = 25.4 millimeters

14.4 Additional Fractional Inch to Millimeter Equivalents

Inches		Millimeters
Fractions	Decimals	
	0.00394	0.1
	0.00787	0.2
	0.01	0.254
	0.01181	0.3
1/64	0.015625	0.3969
	0.01575	0.4
	0.01969	0.5
	0.02	0.508
	0.02362	0.6
	0.02756	0.7
	0.03	0.762
1/32	0.03125	0.7938
	0.0315	0.8
	0.03543	0.9
	0.03937	1.0
	0.04	1.016
3/64	0.046875	1.1906
	0.05	1.27
	0.06	1.524
1/16	0.0625	1.5875
	0.07	1.778
5/64	0.078125	1.9844
	0.07874	2.0
	0.08	2.032
	0.09	2.286
3/32	0.09375	2.3812
	0.1	2.54
7/64	0.109375	2.7781
	0.11	2.794
	0.11811	3.0
	0.12	3.048
1/8	0.125	3.175
	0.13	3.302
	0.14	3.556

Inches		Millimeters
Fractions	Decimals	
9/64	0.140625	3.5719
	0.15	3.810
5/32	0.15625	3.9688
	0.15748	4.0
	0.16	4.064
	0.17	4.318
11/64	0.171875	4.3656
	0.18	4.572
3/16	0.1875	4.7625
	0.19	4.826
	0.19685	5.0
	0.2	5.08
13/64	0.203125	5.1594
	0.21	5.334
7/32	0.21875	5.5562
	0.22	5.588
	0.23	5.842
15/64	0.234375	5.9531
	0.23622	6.0
	0.24	6.096
1/4	0.25	6.35
	0.26	6.604
17/64	0.265625	6.7469
	0.27	6.858
	0.27559	7.0
	0.28	7.112
9/32	0.28125	7.1438
	0.29	7.366
19/64	0.296875	7.5406
	0.30	7.62
	0.31	7.874
5/16	0.3125	7.9375
	0.31496	8.0
	0.32	8.128

Inches		Millimeters
Fractions	Decimals	
21/64	0.328125	8.3344
	0.33	8.382
	0.34	8.636
11/32	0.34375	8.7312
	0.35	8.89
	0.35433	9.0
23/64	0.359375	9.1281
	0.36	9.144
	0.37	9.398
3/8	0.375	9.525
	0.38	9.652
	0.39	9.906
25/64	0.390625	9.9219
	0.39370	10.0
	0.40	10.16
13/32	0.40625	10.3188
	0.41	10.414
	0.42	10.668
27/64	0.421875	10.7156
	0.43	10.922
	0.43307	11.0
7/16	0.4375	11.1125
	0.44	11.176
	0.45	11.430
29/64	0.453125	11.5094
	0.46	11.684
15/32	0.46875	11.9062
	0.47	11.938
	0.47244	12.0
	0.48	12.192
31/64	0.484375	12.3031
	0.49	12.446
1/2	0.50	12.7
	0.51	12.954
	0.51181	13.0

14.4 Additional Fractional Inch to Millimeter Equivalents, continued.

Inches		Millimeters
Fractions	Decimals	
33/64	0.515625	13.0969
	0.52	13.208
	0.53	13.462
17/32	0.53125	13.4938
	0.54	13.716
35/64	0.546875	13.8906
	0.55	13.970
	0.55118	14.0
	0.56	14.224
9/16	0.5625	14.2875
	0.57	14.478
37/64	0.578125	14.6844
	0.58	14.732
	0.59	14.986
	0.59055	15.0
19/32	0.59375	15.0812
	0.60	15.24
39/64	0.609375	15.4781
	0.61	15.494
	0.62	15.748
5/8	0.625	15.875
	0.62992	16.0
	0.63	16.002
	0.64	16.256
41/64	0.640625	16.2719
	0.65	16.510
21/32	0.65625	16.6688
	0.66	16.764
	0.66929	17.0
	0.67	17.018
43/64	0.671875	17.0656
	0.68	17.272
11/16	0.6875	17.4625
	0.69	17.526
	0.70	17.78
45/64	0.703125	17.8594
	0.70866	18.0
	0.71	18.034
23/32	0.71875	18.2562
	0.72	18.288
	0.73	18.542
47/64	0.734375	18.6531
	0.74	18.796
	0.74803	19.0
3/4	0.75	19.050
	0.76	19.304
49/64	0.765625	19.4469
	0.77	19.558
	0.78	19.812
25/32	0.78125	19.8438
	0.78740	20.0
	0.79	20.066
51/64	0.796875	20.2406
	0.80	20.320
	0.81	20.574
13/16	0.8125	20.6375
	0.82	20.828
	0.82677	21.0
53/64	0.828125	21.0344
	0.83	21.082
	0.84	21.336
27/32	0.84375	21.4312
	0.85	21.590
55/64	0.859375	21.8281
	0.86	21.844
	0.86614	22.0
	0.87	22.098
7/8	0.875	22.225
	0.88	22.352
	0.89	22.606
57/64	0.890625	22.6219
	0.90	22.860
	0.90551	23.0
29/32	0.90625	23.0188
	0.91	23.114
	0.92	23.368
59/64	0.921875	23.4156
	0.93	23.622
15/16	0.9375	23.8125
	0.94	23.876
	0.94488	24.0
	0.95	24.130
61/64	0.953125	24.2094
	0.96	24.384
31/32	0.96875	24.6062
	0.97	24.638
	0.98	24.892
	0.98425	25.0
63/64	0.984375	25.0031
	0.99	25.146
1	1.00000	25.4000

14.5 Area Equivalents

Note: Use multiplier at convergence of row and column	Square Meters	Square Inches	Square Feet	Square Miles	Square Kilometers
Square Meters	1	1.5500e3	10.7639	3.861 x 10^{-7}	1 x 10^{-6}
Square Inches	6.4516e-4	1	6.944 x 10^{-3}	2.491 x 10^{-10}	6.452 x 10^{-10}
Square Feet	0.0929	144	1	3.587x 10^{-8}	9.29 x 10^{-8}
Square Miles	2,589,999	–	2.7878e7	1	2.59
Square Kilometers	1,000,000	–	10,763,867	0.3861	1

1 square meter = 10,000 square centimeters.
1 square millimeter = 0.01 square centimeter = 0.00155 square inches.

14.6 Volume Equivalents

Note: Use multiplier at convergence of row and column	Cubic Decimeters (Liters)	Cubic Inches	Cubic Feet	U.S. Quart	U.S. Gallon	Imperial Gallon	U.S. Barrel (Petroleum)
Cubic Decimeters (Liters)	1	61.0234	0.03531	1.05668	0.264178	0.220083	0.00629
Cubic Inches	0.01639	1	5.787 x 10^{-4}	0.01732	0.004329	0.003606	0.000103
Cubic Feet	28.317	1728	1	29.9221	7.48055	6.22888	0.1781
U.S. Quart	0.94636	57.75	0.03342	1	0.25	0.2082	0.00595
U.S. Gallon	3.78543	231	0.13368	4	1	0.833	0.02381
Imperial Gallon	4.54374	277.274	0.16054	4.80128	1.20032	1	0.02877
U.S. Barrel (Petroleum)	158.98	9702	5.6146	168	42	34.973	1

1 cubic meter = 1,000,000 cubic centimeters.
1 liter = 1000 milliliters = 1000 cubic centimeters.

14.7 Volume Rate Equivalents

Note: Use multiplier at convergence of row and column	Liters Per Minute	Cubic Meters Per Hour	Cubic Feet Per Hour	Liters Per Hour	U.S. Gallon Per Minute	U.S. Barrel Per Day
Liters Per Minute	1	0.06	2.1189	60	0.264178	9.057
Cubic Meters Per Hour	16.667	1	35.314	1000	4.403	151
Cubic Feet Per Hour	0.4719	0.028317	1	28.317	0.1247	4.2746
Liters Per Hour	0.016667	0.001	0.035314	1	0.004403	0.151
U.S. Gallon Per Minute	3.785	0.2273	8.0208	227.3	1	34.28
U.S. Barrel Per Day	0.1104	0.006624	0.23394	6.624	0.02917	1

14.8 Mass Conversion — Pounds to Kilograms

Pounds	0	1	2	3	4	5	6	7	8	9
	Kilograms									
0	0.00	0.45	0.91	1.36	1.81	2.27	2.72	3.18	3.63	4.08
10	4.54	4.99	5.44	5.90	6.35	6.80	7.26	7.71	8.16	8.62
20	9.07	9.53	9.98	10.43	10.89	11.34	11.79	12.25	12.70	13.15
30	13.61	14.06	14.52	14.97	15.42	15.88	16.33	16.78	17.24	17.69
40	18.14	18.60	19.05	19.50	19.96	20.41	20.87	21.32	21.77	22.23
50	22.68	23.13	23.59	24.04	24.49	24.95	25.40	25.86	26.31	26.76
60	27.22	27.67	28.12	28.58	29.03	29.48	29.94	30.39	30.84	31.30
70	31.75	32.21	32.66	33.11	33.57	34.02	34.47	34.93	35.38	35.83
80	36.29	36.74	37.20	37.65	38.10	38.56	39.01	39.46	39.92	40.37
90	40.82	41.28	41.73	42.18	42.64	43.09	43.55	44.00	44.45	44.91

14.9 Pressure Equivalents

Note: Use multiplier at convergence of row and column	Kg/cm²	Lb/in²	Atm.	Bar	In. of Hg. (@ 32 °F)	Kilo-pascals	In. of Water (@ 60 °F)	Ft. of Water (@ 60 °F)
Kg/cm²	1	14.22	0.9678	0.98067	28.96	98.067	394.05	32.84
Lb/in²	0.07031	1	0.06804	0.06895	2.036	6.895	27.7	2.309
Atm.	1.0332	14.696	1	1.01325	29.92	101.325	407.14	33.93
Bar	1.01972	14.5038	0.98692	1	29.53	100	402.156	33.513
In. of Hg.	0.03453	0.4912	0.03342	0.033864	1	3.3864	13.61	11.134
Kilopascals	0.0101972	0.145038	0.0098696	0.01	0.2953	1	4.02156	0.33513
In. of Water	0.002538	0.0361	0.002456	0.00249	0.07349	0.249	1	0.0833
Ft. of Water	0.03045	0.4332	0.02947	0.029839	0.8819	2.9839	12	1

1 ounce/in² = 0.0625 lbs./in²

14.10 Pressure Conversion — psi to Bar

psi	0	1	2	3	4
	Bar				
0	0.000000	0.068948	0.137895	0.206843	0.275790
10	0.689476	0.758423	0.827371	0.896318	0.965266
20	1.378951	1.447899	1.516847	1.585794	1.654742
30	2.068427	2.137375	2.206322	2.275270	2.344217
40	2.757903	2.826850	2.895798	2.964746	3.033693
50	3.447379	3.516326	3.585274	3.654221	3.723169
60	4.136854	4.205802	4.274750	4.343697	4.412645
70	4.826330	4.895278	4.964225	5.033173	5.102120
80	5.515806	5.584753	5.653701	5.722649	5.791596
90	6.205282	6.274229	6.343177	6.412124	6.481072
100	6.894757	6.963705	7.032652	7.101600	7.170548

Note: To convert to kilopascals, move decimal point two positions to right; to convert to Megapascals, move decimal point one position to left. For example, 30 psi = 2.068427 bar = 206.8427 kPa = 0.2068427 MPa.
Note: Round off decimal points to provide no more than the desired degree of accuracy.

psi	5	6	7	8	9
	Bar				
0	0.344738	0.413685	0.482633	0.551581	0.620528
10	1.034214	1.103161	1.172109	1.241056	1.310004
20	1.723689	1.792637	1.861584	1.930532	1.999480
30	2.413165	2.482113	2.551060	2.620008	2.688955
40	3.102641	3.171588	3.240536	3.309484	3.378431
50	3.792117	3.861064	3.930012	3.998959	4.067907
60	4.481592	4.550540	4.619487	4.688435	4.757383
70	5.171068	5.240016	5.308963	5.377911	5.446858
80	5.860544	5.929491	5.998439	6.067386	6.136334
90	6.550019	6.618967	6.687915	6.756862	6.825810
100	7.239495	7.308443	7.377390	7.446338	7.515285

Note: To convert to kilopascals, move decimal point two positions to right; to convert to Megapascals, move decimal point one position to left. For example, 30 psi = 2.068427 bar = 206.8427 kPa = 0.2068427 MPa.
Note: Round off decimal points to provide no more than the desired degree of accuracy.

14.11 Temperature Conversion Formulas

To Covert From	To	Substitute in Formula
Degrees Celsius	Degrees Fahrenheit	(°C x 9/5) + 32
Degrees Celsius	Kelvin	(°C + 273.16)
Degrees Fahrenheit	Degrees Celsius	(°F−32) x 5/9
Degrees Fahrenheit	Degrees Rankine	(°F + 459.69)

14.12 Temperature Conversions

°F	Temper-ature in °F or °C to be Converted	°C
	-459.69	-273.16
	-450	-267.78
	-440	-262.22
	-430	-256.67
	-420	-251.11
	-410	-245.56
	-400	-240.00
	-390	-234.44
	-380	-228.89
	-370	-223.33
	-360	-217.78
	-350	-212.22
	-340	-206.67
	-330	-201.11
	-320	-195.56
	-310	-190.00
	-300	-184.44
	-290	-178.89
	-280	-173.33
-459.69	-273.16	-169.53
-457.6	-272	-168.89
-454.0	-270	-167.78
-436.0	-260	-162.22
-418.0	-250	-156.67
-400.0	-240	-151.11
-382.0	-230	-145.56
-364.0	-220	-140.00
-346.0	-210	-134.44
-328.0	-200	-128.89
-310.0	-190	-123.33
-292.0	-180	-117.78
-274.0	-170	-112.22
-256.0	-160	-106.67
-238.0	-150	-101.11

°F	Temper-ature in °F or °C to be Converted	°C
-220.0	-140	-95.56
-202.0	-130	-90.00
-184.0	-120	-84.44
-166.0	-110	-78.89
-148.0	-100	-73.33
-139.0	-95	-70.56
-130.0	-90	-67.78
-121.0	-85	-65.00
-112.0	-80	-62.22
-103.0	-75	-59.45
-94.0	-70	-56.67
-85.0	-65	-53.89
-76.0	-60	-51.11
-67.0	-55	-48.34
-58.0	-50	-45.56
-49.0	-45	-42.78
-40.0	-40	-40.00
-36.4	-38	-38.89
-32.8	-36	-37.78
-29.2	-34	-36.67
-25.6	-32	-35.56
-22.0	-30	-34.44
-18.4	-28	-33.33
-14.8	-26	-32.22
-11.2	-24	-31.11
-7.6	-22	-30.00
-4.0	-20	-28.89
-0.4	-18	-27.78
3.2	-16	-26.67
6.8	-14	-25.56
10.4	-12	-24.44
14.0	-10	-23.33
17.6	-8	-22.22
21.2	-6	-21.11

°F	Temper-ature in °F or °C to be Converted	°C
24.8	-4	-20.00
28.4	-2	-18.89
32.0	0	-17.8
35.6	2	-16.7
39.2	4	-15.6
42.8	6	-14.4
46.4	8	-13.3
50.0	10	-12.2
53.6	12	-11.1
57.2	14	-10.0
60.8	16	-8.89
64.4	18	-7.78
68.0	20	-6.67
71.6	22	-5.56
75.2	24	-4.44
78.8	26	-3.33
82.4	28	-2.22
86.0	30	-1.11
89.6	32	0
93.2	34	1.11
96.8	36	2.22
100.4	38	3.33
104.0	40	4.44
107.6	42	5.56
111.2	44	6.67
114.8	46	7.78
118.4	48	8.89
122.0	50	10.0
125.6	52	11.1
129.2	54	12.2
132.8	56	13.3
136.4	58	14.4
140.0	60	15.6
143.6	62	16.7

14.12 Temperature Conversions, continued.

°F	Temperature in °F or °C to be Converted	°C
147.2	64	17.8
150.8	66	18.9
154.4	68	20.0
158.0	70	21.1
161.6	72	22.2
165.2	74	23.3
168.8	76	24.4
172.4	78	25.6
176.0	80	26.7
179.6	82	27.8
183.2	84	28.9
186.8	86	30.0
190.4	88	31.1
194.0	90	32.2
197.6	92	33.3
201.2	94	34.4
204.8	96	35.6
208.4	98	36.7
212.0	100	37.8
230.0	110	43.3
248.0	120	48.9
266.0	130	54.4
284.0	140	60.0
302.0	150	65.6
320.0	160	71.1
338.0	170	76.7
356.0	180	82.2
374.0	190	87.8
392.0	200	93.3
410.0	210	98.9
428.0	220	104.4
446.0	230	110.0
464.0	240	115.6
482.0	250	121.1
500.0	260	126.7
518.0	270	132.2
536.0	280	137.8
554.0	290	143.3
572.0	300	148.9
590.0	310	154.4
608.0	320	160.0
626.0	330	165.6
644.0	340	171.1
662.0	350	176.7
680.0	360	182.2
698.0	370	187.8
716.0	380	193.3
734.0	390	198.9
752.0	400	204.4
770.0	410	210.0
788.0	420	215.6
806.0	430	221.1
824.0	440	226.7
842.0	450	232.2
860.0	460	237.8
878.0	470	243.3
896.0	480	248.9
914.0	490	254.4
932.0	500	260.0
950.0	510	265.6
968.0	520	271.1
986.0	530	276.7
1004.0	540	282.2
1022.0	550	287.8
1040.0	560	293.3
1058.0	570	298.9
1076.0	580	304.4
1094.0	590	310.0
1112.0	600	315.6
1130.0	610	321.1
1148.0	620	326.7
1166.0	630	332.2
1184.0	640	337.8
1202.0	650	343.3
1220.0	660	348.9
1238.0	670	354.4
1256.0	680	360.0
1274.0	690	365.6
1292.0	700	371.1
1310.0	710	376.7
1328.0	720	382.2
1346.0	730	387.8
1364.0	740	393.3
1382.0	750	398.9
1400.0	760	404.4
1418.0	770	410.0
1436.0	780	415.6
1454.0	790	421.1
1472.0	800	426.7
1490.0	810	432.2
1508.0	820	437.8
1526.0	830	443.3
1544.0	840	448.9
1562.0	850	454.4
1580.0	860	460.0
1598.0	870	465.6
1616.0	880	471.1
1634.0	890	476.7
1652.0	900	482.2
1670.0	910	487.8
1688.0	920	493.3
1706.0	930	498.9

14.12 Temperature Conversions, continued.

°F	Temper-ature in °F or °C to be Converted	°C
1724.0	940	504.4
1742.0	950	510.0
1760.0	960	515.6
1778.0	970	521.1
1796.0	980	526.7
1814.0	990	532.2
1832.0	1000	537.8
1850.0	1010	543.3
1868.0	1020	548.9
1886.0	1030	554.4
1904.0	1040	560.0
1922.0	1050	565.6
1940.0	1060	571.1
1958.0	1070	576.7
1976.0	1080	582.2
1994.0	1090	587.8
2012.0	1100	593.3
2030.0	1110	598.9
2048.0	1120	604.4

°F	Temper-ature in °F or °C to be Converted	°C
2066.0	1130	610.0
2084.0	1140	615.6
2102.0	1150	621.1
2120.0	1160	626.7
2138.0	1170	632.2
2156.0	1180	637.8
2174.0	1190	643.3
2192.0	1200	648.9
2210.0	1210	654.4
2228.0	1220	660.0
2246.0	1230	665.6
2264.0	1240	671.1
2282.0	1250	676.7
2300.0	1260	682.2
2318.0	1270	687.8
2336.0	1280	693.3
2354.0	1290	698.9
2372.0	1300	704.4
2390.0	1310	710.0
2408.0	1320	715.6

°F	Temper-ature in °F or °C to be Converted	°C
2426.0	1330	721.1
2444.0	1340	726.7
2462.0	1350	732.2
2480.0	1360	737.8
2498.0	1370	743.3
2516.0	1380	748.9
2534.0	1390	754.4
2552.0	1400	760.0
2570.0	1410	765.6
2588.0	1420	771.1
2606.0	1430	776.7
2624.0	1440	782.2
2642.0	1450	787.0
2660.0	1460	793.3
2678.0	1470	798.9
2696.0	1480	804.4
2714.0	1490	810.0
2732.0	1500	815.6

14.13 API and Baumé Gravity Tables and Weight Factors

API Gravity	Baumé Gravity	Specific Gravity	Lb/U.S. Gravity	U.S. gal/lb
0	10.247	1.0760	8.962	0.1116
1	9.223	1.0679	8.895	0.1124
2	8.198	1.0599	8.828	0.1133
3	7.173	1.0520	8.762	0.1141
4	6.148	1.0443	8.698	0.1150
5	5.124	1.0366	8.634	0.1158
6	4.099	1.0291	8.571	0.1167
7	3.074	1.0217	8.509	0.1175
8	2.049	1.0143	8.448	0.1184
9	1.025	1.0071	8.388	0.1192
10	10.00	1.0000	8.328	0.1201
11	10.99	0.9930	8.270	0.1209
12	11.98	0.9861	8.212	0.1218
13	12.97	0.9792	8.155	0.1226
14	13.96	0.9725	8.099	0.1235
15	14.95	0.9659	8.044	0.1243
16	15.94	0.9593	7.989	0.1252
17	16.93	0.9529	7.935	0.1260
18	17.92	0.9465	7.882	0.1269
19	18.90	0.9402	7.830	0.1277
20	19.89	0.9340	7.778	0.1286
21	20.88	0.9279	7.727	0.1294
22	21.87	0.9218	7.676	0.1303
23	22.86	0.9159	7.627	0.1311
24	23.85	0.9100	7.578	0.1320
25	24.84	0.9042	7.529	0.1328
26	25.83	0.8984	7.481	0.1337
27	26.82	0.8927	7.434	0.1345
28	27.81	0.8871	7.387	0.1354
29	28.80	0.8816	7.341	0.1362
30	29.79	0.8762	7.296	0.1371
31	30.78	0.8708	7.251	0.1379
32	31.77	0.8654	7.206	0.1388
33	32.76	0.8602	7.163	0.1396
34	33.75	0.8550	7.119	0.1405
35	34.73	0.8498	7.076	0.1413
36	35.72	0.8448	7.034	0.1422
37	36.71	0.8398	6.993	0.1430
38	37.70	0.8348	6.951	0.1439
39	38.69	0.8299	6.910	0.1447
40	39.68	0.8251	6.870	0.1456
41	40.67	0.8203	6.830	0.1464
42	41.66	0.8155	6.790	0.1473
43	42.65	0.8109	6.752	0.1481
44	43.64	0.8063	6.713	0.1490
45	44.63	0.8017	6.675	0.1498
46	45.62	0.7972	6.637	0.1507
47	50.61	0.7927	6.600	0.1515
48	50.60	0.7883	6.563	0.1524
49	50.59	0.7839	6.526	0.1532
50	50.58	0.7796	6.490	0.1541
51	50.57	0.7753	6.455	0.1549
52	51.55	0.7711	6.420	0.1558
53	52.54	0.7669	6.385	0.1566
54	53.53	0.7628	6.350	0.1575
55	54.52	0.7587	6.316	0.1583
56	55.51	0.7547	6.283	0.1592
57	56.50	0.7507	6.249	0.1600
58	57.49	0.7467	6.216	0.1609
59	58.48	0.7428	6.184	0.1617
60	59.47	0.7389	6.151	0.1626
61	60.46	0.7351	6.119	0.1634
62	61.45	0.7313	6.087	0.1643
63	62.44	0.7275	6.056	0.1651
64	63.43	0.7238	6.025	0.1660

14.13 API and Baumé Gravity Tables and Weight Factors, continued.

API Gravity	Baumé Gravity	Specific Gravity	Lb/U.S. Gravity	U.S. gal/lb
65	64.42	0.7201	5.994	0.1668
66	65.41	0.7165	5.964	0.1677
67	66.40	0.7128	5.934	0.1685
68	67.39	0.7093	5.904	0.1694
69	68.37	0.7057	5.874	0.1702
70	69.36	0.7022	5.845	0.1711
71	70.35	0.6988	5.817	0.1719
72	71.34	0.6953	5.788	0.1728
73	72.33	0.6919	5.759	0.1736
74	73.32	0.6886	5.731	0.1745
75	74.31	0.6852	5.703	0.1753
76	75.30	0.6819	5.676	0.1762
77	76.29	0.6787	5.649	0.1770
78	77.28	0.6754	5.622	0.1779
79	78.27	0.6722	5.595	0.1787
80	79.26	0.6690	5.568	0.1796
81	80.25	0.6659	5.542	0.1804
82	81.24	0.6628	5.516	0.1813

API Gravity	Baumé Gravity	Specific Gravity	Lb/U.S. Gravity	U.S. gal/lb
83	82.23	0.6597	5.491	0.1821
84	83.22	0.6566	5.465	0.1830
85	84.20	0.6536	5.440	0.1838
86	85.19	0.6506	5.415	0.1847
87	86.18	0.6476	5.390	0.1855
88	87.17	0.6446	5.365	0.1864
89	88.16	0.6417	5.341	0.1872
90	89.15	0.6388	5.316	0.1881
91	90.14	0.6360	5.293	0.1889
92	91.13	0.6331	5.269	0.1898
93	92.12	0.6303	5.246	0.1906
94	93.11	0.6275	5.222	0.1915
95	94.10	0.6247	5.199	0.1924
96	95.09	0.6220	5.176	0.1932
97	96.08	0.6193	5.154	0.1940
98	97.07	0.6166	5.131	0.1949
99	98.06	0.6139	5.109	0.1957
100	99.05	0.6112	5.086	0.1966

The relation of degrees Baumé or API to specific gravity is expressed by the following formulas:

For liquids lighter than water:

$$\text{Degrees Baumé} = \frac{140}{G} - 130 \;, \qquad G = \frac{140}{130 + \text{degrees Baumé}}$$

$$\text{Degrees API} = \frac{141.5}{G} - 131.5 \;, \qquad G = \frac{141.5}{131.5 + \text{degrees API}}$$

For liquids heavier than water:

$$\text{Degrees Baumé} = 145 - \frac{145}{G} \;, \qquad G = \frac{145}{145 - \text{degrees Baumé}}$$

G = specific gravity = ratio of the weight of a given volume of oil at 60 °F (15.5 °C) to the weight of the same volume of water at 60 °F (15.5 °C).

The previous tables are based on the weight of 1 gallon (U.S.) of oil with a volume of 231 in^3 at 60 °F (15.5 °C) in air at 760 mm pressure and 50% humidity. Assumed weight of 1 gallon of water at 60 °F (15.5 °C) in air is 8.32828 pounds.

To determine the resulting gravity by mixing oils of different gravities:

$$G(mix) = \frac{md_1 + nd_2}{m + n}$$

$G(mix)$ = Specific gravity of mixture

Where:

m = Volume fraction of oil of d_1 density

d_1 = Specific gravity of m oil

n = Volume fraction of oil of d_2 density

d_2 = Specific gravity of n oil

14.14 Other Useful Conversions

To Covert From	To	Substitute in Formula
Cu Ft (Methane)	BTU	1000 (approx.)
Cu Ft of Water	Lb of Water	62.4
Degrees	Radians	0.01745
Gal	Lb of Water	8.336
Grams	Ounces	0.0352
Horsepower (mechanical)	Ft Lb per Min	33,000
Horsepower (electrical)	Watts	746
Kg	Lb	2.205
Kg per Cu Meter	Lb per Cu Ft	0.06243
Kilowatts	Horsepower	1.341
Lb	Kg	0.4536
Lb of Air (14.7 psia and 60 °F)	Cu Ft of Air	13.1
Lb per Cu Ft	Kg per Cu Meter	16.0184
Lb per Hr (Gas)	Std Cu Ft per Hr	13.1/Specific Gravity
Lb per Hr (Water)	Gal per Min	0.002
Lb per Sec (Gas)	Std Cu Ft per Hr	0.41793/Specific Gravity
Radians	Degrees	57.3
Scfh Air	Scfh Propane	0.81
Scfh Air	Scfh Butane	0.71
Scfh Air	Scfh 0.6 Natural Gas	1.29
Scfh	Cu Meters per Hr	0.028317

14.15 Metric Prefixes and Suffixes

Multiplication Factor	Prefix	Symbol
1 000 000 000 000 000 000 = 10^{18}	exa	E
1 000 000 000 000 000 = 10^{15}	peta	P
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto	h
10 = 10^{1}	deca	da
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	μ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

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Glossary

A

Accuracy
The closeness of agreement of the meter reading to a known value.

Actual Volumetric Flow
The flow rate of a fluid in units of volume per time where the volume is at flowing conditions.

AGA
An acronym for American Gas Association, which is an American trade organization representing natural gas producers and appliance manufacturers.

Alignment Ring
A ring that centers the meter wafer in the pipe during installation. They are made for each nominal pipe size.

Ambient Temperature Effect
Measurement errors that may result due to differences in electronics performance at varying temperatures.

Analog Signal
Analog 4-20 mA signal is a common form of communication between field devices and a control system. This utilizes a current loop in the wiring to transmit a measured variable, such as pressure or flow rate.

Analog Trim
Analog trim adjusts the transmitter's analog output to match the plant standard of the control loop. Specifically, it allows manipulation of the transmitter's current output at the 4 and 20 mA points by adjusting the digital to analog signal conversion.

Annubar
Rosemount Annubar™ is an Emerson trade name for an averaging pitot tube primary element.

Area Meter
A primary element where a change in the area of the flowing conduit is used to generate a differential pressure. Examples include orifice plate, Venturi tube, flow nozzle, wedge meter, and cone meter.

As-Found Calibration
The tested and recorded output of the transmitter during the verification process and prior to any adjustments being made. If any adjustments are made, the output is checked again and recorded.

As-Left Calibration
The tested and recorded output of the transmitter during the verification process after adjustments are made and the output is checked and recorded again.

ASME
An acronym for American Society of Mechanical Engineers.

Averaging Pitot Tube
A type of primary element that is similar in operation to a single point pitot tube, except that it measures velocities across the pipe diameter instead of at a single point.

B

Bernoulli's Equation
An equation for fluid flow that states as fluid velocity increases, it results in a corresponding decrease in static pressure.

Bernoulli's Principle
As the velocity of a fluid increases, there is a simultaneous decrease in the fluid pressure (i.e., potential energy).

Biplanar Manifold
A traditional style of connecting to a pressure transmitter, this manifold style has two pressure ports on the side of the manifold, which results in a heavier connection system.

Bleeding
Action of removing unwanted air or liquid from impulse lines so that the impulse lines are filled with a single fluid phase, and measurement errors are prevented.

Body (Gravitational) Energy
Potential energy present in a mass (or object) due to its position at height. An example is a rock at the top of a hill.

C

Calibrated Performance
A differential pressure primary element that includes a calibration certificate for the specific flow element from a traceable flow calibration laboratory.

Calibrated Uncertainty
The expected error or accuracy of a meter system that has had its performance verified against a known standard during the manufacturing process.

Calibration
A process by which an instrument's performance is compared against a known standard to verify its capabilities and minimize errors.

Calibration Factor
A correction value used to adjust the output of a meter to match the known standard it was compared against.

Capacitive Sensor
A sensor consisting of two plates and a central, flexible diaphragm that is used to measure differential pressure.

Communication
Communication is the transmission of information between two or more points (e.g., transmitter and controller) without alteration of sequence or structure of the information.

Compact Orifice Plate
An orifice flow meter with the orifice built into a wafer that allows the installation between standard (not orifice) flanges, and incorporates the DP transmitter for a complete flow meter assembly.

Composite Accuracy
Accuracy as determined by other performance values such as linearity, repeatability, and hysteresis.

Compressible Flow
Flow of a fluid that changes volume depending upon the pressure of the system.

Concentric Sharp-Edged Orifice Plate
Considered the standard orifice plate design, this type of orifice plate has a sharp upstream edge and commonly includes a bevel around the bore on the downstream side of the plate.

Conditioning Orifice Plate
A proprietary Emerson design that includes four holes in the orifice plate rather than a single hole to provide enhanced accuracy in installations with limited straight pipe run.

Cone Meter
A primary element that uses a cone-shaped body in a pipe spool to create a restriction.

Conical Entrance Orifice Plate
An orifice plate design that includes a bevel on the upstream side of the plate and provides improved performance in high-viscosity liquids.

Continuity Equation
An equation that states that what flows into a pipe must come out of the pipe. The flow rate is constant at any section of the pipe.

Coplanar Manifold
An Emerson proprietary instrument connection design that has both pressure taps in the same plane on the bottom of the transmitter. This reduces the weight and bolting requirements of the overall instrument system.

Corner Tap
The tap edge is at the orifice plate surface. They are typically used for orifice plates in smaller diameter pipes where the small orifice bore would put the vena-contracta close to the plate. They are sometimes used with a pressure-averaging piezometer, in which case they require more precision to machine.

Custody Transfer
Measurement that is related to the buying and selling of the product being measured.

D

Damping
A transmitter setting that changes the transmitter response time. Higher values can smooth out variations in output readings caused by noise in the process measurement.

DCS
An acronym for distributed control system.

Developed Flow
Flow that will not change or develop further as the fluid travels down a straight pipe section. It has a stable velocity field.

Differential Pressure (DP)
The difference in static pressure between two points in a fluid system imparted due to a restriction in the fluid conduit or pipe.

Differential Pressure Flow Meter
A measurement system composed of a primary element (such as an orifice plate) and a secondary element (such as a DP transmitter) that allows measurement of fluid flow through a conduit.

Differential Pressure Turndown
The differential pressure reading at the maximum flow rate divided by the differential pressure reading at the minimum flow rate.

Digital Signal
A signal that represents the value of a parameter by coding a number using the binary system in a series of on/off pulses. A digital signal does not continuously change like an analog signal; digital signals jump directly from the on (1) to the off (0) state.

Discharge Coefficient
A factor that accounts for the viscous losses and characterizes the behavior of the primary element as flow changes over the range of measurement.

Drag Coefficient
A change in the flow coefficient over the operating range as a result of changes in local pressure on the surface relative to the stagnation pressure.

Drag Port
A location for the low-pressure measurement that is located on the side of an averaging pitot tube shape.

E

Eccentric Orifice Plate
An orifice plate design that allows the bore to be positioned at the top or bottom of the pipe, which can prevent buildup of gases or liquids in front of the plate when multiple phases are present (such as steam with condensate).

Engineering Assistant (EA)
An Emerson software program that can be used to configure a Rosemount MultiVariable transmitter.

Enthalpy
A thermodynamic term referring to the total heat (energy) content of a system.

F

Flange-Lok Mounting
A mounting system that allows a Pak-Lok Annubar primary element to be used on a normal flanged connection port.

Flange
A collar or rim on a pipe that attaches to other pipes or instruments.

Flange Tap
A type of orifice tape that positions the center of the pressure tap 1 in. (25.4 mm) from the surface of the orifice plate. This is the most common tap type used with orifice flanges.

Flanged Mounting
An Annubar primary element mounting style that uses an averaging pitot tube welded into a blind flange (e.g. ASME, DIN, or JIS) for mounting on the pipe system.

Flo-Tap Mounting
An Annubar primary element mounting system that allows insertion or retraction of the sensor under pressure and flowing conditions.

Flow
Fluid movement in an organized fashion from one location to another.

Flow Coefficient
The variable that characterizes the true behavior of a flow meter and considers the effects of a real (rather than ideal) fluid in a pipe or conduit.

Flow Computer
An electronic device that compensates the volumetric flow measurement for changes in density and other factors to arrive at a more accurate flow rate. It may also incorporate logging or totalizing functions.

Flow Nozzle
A type of area DP flow meter that is designed as a contoured shape with a smooth entrance profile and an abrupt exit.

Flow Rate
The volume of fluid passing through a particular point in a pipe over a specific time period.

Flow Straightener
A device that is installed in a pipe or other conduit to correct the flow profile and improve measurement accuracy when the measurement point is located near a pipe disturbance such as an elbow.

Fluid Density
The mass per unit volume of a fluid.

Fluid Viscosity
A fluid's resistance to flow caused by the shearing stress within the flowing fluid and between the flowing fluid and its conduit.

FOUNDATION™ Fieldbus
A two-way, all digital, multi-drop serial communication protocol that uses input/output (I/O) function blocks to interface with and represent the physical and information worlds.

G

Gas Expansion Factor
The factor, also known as expansibility, accounts for the change in the density of the gas as the flow goes through or around a meter. The factor is determined experimentally from data and is calculated using an equation.

H

Handheld Communicator
A portable device (sometimes known as a HART communicator) that allows local interaction and configuration of a field instrument.

HART® (Highway Addressable Remote Transducer)
A protocol that communicates across legacy 4-20 mA instrumentation wiring by treating the 4-20 mA signal as a carrier and overlaying smart protocol communications on it.

Housing
A part of a transmitter that protects the electronics.

Hysteresis
The difference in readings at a set point when the set point is approached from different directions in the test cycle.

I

In-Situ Calibration
A calibration using known conditions. It is performed on a device after it has been installed in a process.

Initial Force Conversion Constant
A conversion factor that equates inertial forces to body forces for the given set of units using Newton's first law of motion.

Integrated Flow Meter
A DP flow meter that combines a primary element and a DP transmitter into a single component that is factory assembled and configured.

Internal Energy
The energy contained within a system, and that at the most basic level is due to the movement of individual molecules.

ISO
An acronym referring to the International Organization for Standardization, which is an industry standard-setting organization.

K

Kinetic Energy
The energy that an object has by virtue of being in motion. It is the work required to accelerate an object from a rest to its present velocity.

L

Latent Heat
The energy required to drive a phase change such as from a solid to a liquid, or liquid to a gas, without a change in temperature.

Line Pressure Effect
Line pressure effect errors that occur when the characteristics of the sensor are altered under static pressure. This effect, which only applies to DP pressure measurement, is an error that results due to the forces of static pressure that are applied to the sensor.

Linearity
The maximum change in meter performance over a given flow rate range. It is the maximum deviation between the average error curve and a designated straight line.

Liquid Specific Gravity
The ratio of a substance's density to that of a standard, which is commonly water for liquids.

Lockhart-Martinelli Number
A dimensionless factor used to measure the effect of a liquid in a gas and is calculated from the mass flow rate or volumetric flow rate.

Low Flow Cutoff
A configuration parameter that allows a low flow point to be set so that the transmitter will output "0" below a designated measurement threshold.

M

Main Steam Line
The primary steam outlet from a boiler or superheater to a turbine, but it can also be applied to reheat lines from the intermediate turbine stages.

Make Up Water
Treated water that is pumped into a boiler to replace the mass of steam leaving the boiler.

Manifold
A device fitted with several valves that is used to isolate a pressure instrument from the process. It can also sometimes be used for venting or performing a zero trim.

Manometer
A pressure gauge that usually has a U-shaped tube that allows liquid to rise until the pressure is balanced against the weight of the liquid. A scale measures the height difference, which is an indication of pressure.

Mass Flow
The flow rate of a fluid in units of mass per time.

Modbus®
A digital master-slave communication protocol. Modbus is primarily used to communicate, control, and monitor data.

Module
A component of some transmitters that houses the pressure sensing element, and in some cases, additional electronic components.

Multi-Hole Orifice Plate
A generic term to describe an orifice plate with multiple holes, which are designed to provide a consistent downstream flow field that is unaffected by the upstream fluid dynamics. This device reduces the amount of straight pipe required and required while still providing good performance.

Multivariable Transmitter
A DP transmitter that can measure additional process variables including static pressure and temperature.

N

Non-Compressible Flow
A fluid whose density is generally unaffected by changes in pressure.

Non-Newtonian Fluids
A fluid whose viscosity is variable based upon shear stress or applied force.

Non-Proprietary DP Flow Primary Element
A device with a design and specification standard that is in the public domain.

Nozzle
A device designed to control the characteristics of fluid flow as it exits or flows through a pipe.

O

O-Ring
A mechanical gasket designed to be seated in a groove and compressed during assembly to create a seal between two surfaces.

Offset Trim
A signal point calibration method that corrects the offset of the calibration curve to a desired reference point. This is often known as a lower sensor trim, or a zero trim when the reference is zero.

Orifice Beta Ratio
The ratio of the inner diameter of a pipe and the bore size of an orifice plate.

Orifice Bore
The diameter of the hole in the orifice plate itself.

Orifice Plate
A paddle-shaped device with a hole that is designed to be installed between flanges in a piping system and restricts fluid flow or creates a differential pressure.

P

Paddle Style
An orifice plate design that includes a handle.

Pak-Lok Mounting
An Annubar flow meter mounting style that relies upon a packing gland for simple and efficient installation with a secure fit.

Percent of Reading Performance
A performance specification in which the uncertainty of the measurement stays constant as a percent of the displayed value when flow rates change, leading to better performance.

Percent of Span Performance
A performance specification in which the uncertainty of the measurement increases as the flow rate decreases, limiting a device's use over wide turndowns.

Permanent Pressure Loss (PPL)
The decline in system pressure downstream of a primary element due to the fluid turbulence at that point.

Piezometer
An averaging system that measures the pressure around the radius of a pipe to increase the accuracy of the measurement.

Piezoresistive Strain Gauge Sensor
A silicon-based sensor that consists of an array of resistors, called a Wheatstone bridge, which is etched on a silicon substrate.

Pipe Blockage
The percent of the pipe area at the measuring plane taken by the cross-sectional area of the flow sensor probe or cylinder installed at the measuring plane.

Pipe Inside Diameter (ID)
The distance across the inside of the pipe from wall to wall.

Pipe Outside Diameter (OD)
The distance across the pipe including the thickness of the pipe wall.

Pitot Tube
A primary element design that measures the fluid velocity at a single point in a conduit.

Pressure
The force applied to a surface, denoted as a force per unit area.

Pressure Energy
Energy stored in a fluid due to the force applied per unit area.

Pressure-Lock™ Valve Technology
A proprietary Emerson manifold valve technology with improved ease of use and retention under extreme pressure.

Primary Element
A device installed in a pipe that creates a change in pressure, which is proportional to the flow rate. Examples include orifice plates, multi-hole orifice plates, averaging pitot tubes, Venturi tubes, wedge meters, cone meters, and flow nozzles.

Process Connection
A type of connection, such as a manifold, impulse piping, or a primary element, used to connect a transmitter to the process.

PROFIBUS®
A two-way, all digital communication protocol that is fundamentally designed to meet high-speed factory automation needs.

Proprietary Primary Element
A device that is typically exclusive to a manufacturer and is under patent protection and/or the name of the device is under copyright.

Prover
An on-site automated system that provides calibration to ensure flow meters in fiscal or custody transfer service remain in compliance with industry standards.

Q

Quadrant-Edge Orifice Plate
An orifice plate that is used for high-viscosity liquids over a wider range of flow than the conical entrance plate, with a linear discharge coefficient and a lower DP.

R

Radius Tap
It can be an upstream tap at 1 pipe diameter and downstream tap at ½ pipe diameter from the orifice plate surface. It can be installed without special flanges or machined mounting systems by welding couplings to the pipe wall at specified distances.

Rangedown
The upper range limit of a transmitter divided by the minimum span the transmitter can be set to. For example, a transmitter with a 1000 inH_2O upper range limit and a minimum span of 5 inH_2O would have a rangedown of 200:1.

Range Points
A transmitter setting that allows the limits of the transmitter measurement to be set (e.g., the 4-20 mA points).

Rankine Cycle
A thermodynamic cycle that describes the process of generating steam and expanding it through a turbine.

Reference Accuracy
Percent of accuracy of an instrument under controlled conditions, such as a flow laboratory.

Repeatability
Ability of a transmitter to output the same values when operating under the same process and environmental conditions.

Reproducibility
The statistical change in results for a meter used in different conditions, applications, or operators.

Reynolds Number
The ratio of inertial forces to viscous fluids within a fluid.

RTD
An acronym for Resistance Temperature Detector, which is a device that uses changes in electrical resistance to measure a temperature.

S

Safety Instrumented Systems (SIS)
An automated system that takes action to keep a plant safe or shut down a process when abnormal conditions are detected.

Safety Integrity Level (SIL)
A relative level of risk reduction provided by a safety function.

Sampling Meter
A primary element that measures the velocity profile in a pipe at either a single point (such as a pitot tube) or at multiple points (such as an averaging pitot tube).

Saturated Steam
Steam that has just enough enthalpy (heat) to ensure that all the liquid water has turned to steam.

Seals
A secondary diaphragm system between the transmitter isolating diaphragm and the process. Often connected to the transmitter by a filled fluid capillary, seals are used to convey a pressure signal while protecting the pressure transmitter from heat or damaging fluids.

Secondary Element
Part of a DP flow meter that reads the DP generated by the primary element. The secondary element is typically a DP transmitter.

Segmental Orifice Plate
An orifice plate with the hole in the shape of a half-moon to allow sediment and solids to pass through unimpeded.

Sensitivity Factor
A measure of the impact an error for a particular parameter has on the calculated value.

Sensor
Part of an electronic pressure transmitter, it physically responds to changes in input pressure and converts the physical movement into an electrical property, such as capacitance, voltage, inductance, or reluctance.

Sensor Trim
An adjustment that changes the calibration curve associated with the characterization of the transmitter. A sensor trim can either change the slope or the offset of the linear characterization curve.

Short-Form Venturi Tube
A Venturi tube that is made shorter by truncating the exit cone to about 70% of the original length. This increases the Permanent Pressure Loss somewhat, but it is small compared to other area DP meters.

Sizing
The process of matching the most appropriate equipment and technology to the flow conditions specified in the application.

Slope Trim
An adjustment that corrects the slope of the characterization curve using a known reference point. It is also known as the upper sensor trim.

Span
The transmitter span is the region that the transmitter is set to measure, bound by the user set upper range value and lower range value. A transmitter set to measure 0-1000 inH_2O would have a span of 1000 inH_2O (1000 inH_2O – 0 inH_2O = 1000 inH_2O).

Specific Gravity
The ratio of the density of one substance to the density of a reference substance.

Specific Weight
The weight due to gravitational pull of a pure or homogeneous substance per unit volume.

Stability
A measure of a transmitter's consistency in output for a fixed input as a function of time. This is generally defined as a percent of the upper range value for a finite period of time.

Stagnation Pressure
The pressure generated when a moving fluid is brought to rest and the motion converted to pressure without losses.

Standard Volumetric Flow
The flow rate of a fluid in units of volume per time where the volume is at a standard or base set of conditions.

Steam Enthalpy
The total energy (heat) in steam compared to a reference state.

Steady State
A condition in which the variables that define the system (e.g., pressure, temperature, flow, etc.) are unchanging with respect to time.

Straight Piping
A pipe that does not have any valves, fittings, or other disturbances along its length. Different lengths of straight pipe are required depending on the flow technology, but most require some straight pipe ahead of the meter to make an accurate measurement.

Superheated Steam
When saturated steam flows over a surface that is hotter than the steam, heat is added and it becomes superheated. Steam can also become superheated when its pressure is reduced inside an insulated fitting such as a pressure-reducing valve/station.

Super Module
A high-performance, pressure-sensing module that contains the primary analog electronics, characterization data values, and sensing element for Emerson's Rosemount 3051S series of transmitters.

T

Thermowell
A cylindrical fitting used to protect a temperature sensor installed in an industrial process.

Total Energy
The total energy of a system. It is equal to the sum of the kinetic and potential energies.

Total Probable Error (TPE)
Overall performance is defined by the Total Probable Error (TPE). TPE is the accuracy of the instrument in installed conditions. TPE is made up of three things: reference accuracy, ambient temperature effects, and line pressure effects.

Traditional DP Flow Meter
A DP flow meter system consisting of a minimum of three separate components: a primary element, impulse lines, and a DP transmitter. These components are typically ordered component-by-component with parts being assembled on-site.

Turndown
The ratio of the highest over the lowest flow rate that can be read within the stated flow meter performance. It is dependent on the stated accuracy, repeatability, and meter linearity.

Two-Phase Fluid
A state of having gas entrained in a flowing liquid or liquid in a flowing gas. It may cause measurement error if the volume of the entrained fluid is significant enough.

U

Uncalibrated Performance
The specified accuracy of a primary element without calibration against a known standard. This term is interchangeable with Uncalibrated Uncertainty.

Uncalibrated Uncertainty
The specified uncertainty of a primary element without calibration against a known standard. This term is interchangeable with Uncalibrated Performance.

Uncertainty
Expresses the statistical dispersion of results from a single measured quantity. It is often used interchangeably with accuracy on product specifications, but uncertainty is the technically correct term.

Undeveloped Flow
A flow profile that will continue to develop or change as it travels down a straight-pipe section.

Universal Style Plate
An orifice plate without a handle that can be used in a plate holder, orifice fitting, or other device to affix it within the pipe.

Universal Venturi Tube
The Universal Venturi Tube is like a short-form Venturi, but there are two entrance cone sections to keep the flow attached and the section short. The throat section and diffusing or exit cone are also shortened. This reduces the length and retains the low Permanent Pressure Loss.

V

Velocity
The speed of a fluid with a defined direction.

Velocity Profile
The distribution of fluid velocities in a pipe cross section. A profile is said to be fully developed when there is a repeatable profile across the pipe.

Venturi Nozzle
A Venturi meter combined with a nozzle to make a composite meter. An exit cone is attached to a flow nozzle.

Venturi Principle
The difference in pressure of a fluid as it flows through a restriction is related to the area difference, or the difference in the square of the velocity at each section.

Venturi Tube
A flow meter that consists of an entrance section, conical converging section, throat section, and diverging exit section. The DP is taken at taps in the entrance and throat sections and is generated by the Venturi principle.

Verification
A similar process to validation except that no trims or adjustments are performed on the DP flow meter system. It is simply a method that verifies that the flow meter output is within the stated accuracy range.

Vortex Shedding
In fluid dynamics, this refers to an oscillating flow that occurs when a fluid flows past a bluff body at certain velocities.

W

Wedge Meter
An area meter that has a sloping surface on both sides of the restriction to direct the flow under the restriction, thereby minimizing the collection of entrained solids.

Wet Gas
A gas with a small amount of liquid present in the flow stream that can lead to measurement errors.

Wet Leg
A section of impulse piping filled with a heavier fluid than the process to protect the sensing element from harsh process conditions. A common wet leg system is water-filled impulse piping used in conjunction with high temperature steam.

Wet (Quality) Steam
Steam that has liquid content due to boiler carryover or lack of effective condensate removal.

***Wireless*HART®**
A wireless protocol ideally suited for applications that involve instrumentation in hard to reach or unsafe areas.

Z

Zero Trim
A single-point offset adjustment. It is a lower sensor trim (i.e., offset trim) that uses a known reference of zero DP.

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